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SHC62-9015-238
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8 August 1962

OXC-3858
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Processor Progress Report from 1 July 1962 to 1 August 1962

INTRODUCTION

July was a slow month on the project. Most of the experimental work remaining on the contract is held up pending delivery of optical components. Two flight films were received and processed during the month.

TEST AND SIMULATION

A new test target array having a 200 inch focal length was started. This is a composite of many tragets with various overlaps and contrast levels on one 10 foot roll of $9\frac{1}{2}$ inch film. This is similar to test target T115 described in the April report, except for the focal length; i.e. scale of the pattern.

MODIFICATIONS

One cylinder lens was received from Perkin-Elmer on 27 July. This is the interchangeable lens used for the far range. It appears much better than the previous cylinder lenses, but the lens bench tests are not complete as yet. If it is satisfactory, it will be installed to replace one of the poor lenses if the focus and magnification can be maintained. It will not improve the processor performance a great deal until the other cylinder lens is replaced also. We have no firm schedule on the other lens, but it is expected late in August (Perkin-Elmer is on vacation). Diffraction Limited is predicting late August for their first lens.

The new input platen was installed and used. It does not leak! However, its optical surface is easily distorted during mounting. This effect is not serious at the present resolution levels, but it may be a problem later. The new edge guiding technique will allow a modification to reduce the glass area, and increase the thickness which will minimize the warping problem. Further experience has lead to the need for a deeper tray and some provisions to make threading of the film easier. A new tray design is presently under consideration.

The new edge guide mounted in the platen works quite well. The film drive and tracking tests will be done during August.

FLIGHT TESTS

Flight Film S21: This film was received on July 3rd. It contained good information, but its density and contrast were low. The film was correlated twice without good results. It was also duplicated and short sections of runs 1, 2 and 4 cut out and spliced together. This was correlated with both front and rear squint with reasonable results. Figures 1 and 2 show the original film and its correlation.

Flight Film S22: This film was received on July 30th. This film appeared out of focus and no patterns could be found. Figure 3 is typical of this film. No correlation was attempted.

Sensitometry: The flight test program has now come to the point where better sensitometric data and control are necessary. Initial steps in sensitometry based on conventional techniques have pointed out some difficulties in reproducibility of results, and better control is indicated. The first step is to work out some new procedures which will test the sensitometry in a manner meaningful to the coherent radar system. The standard procedure is based on logarithmic scales and is very useful for analysis and control of the portion of the curve indicated in Fig. 4. However, we are interested in the toe of the D -log E curve as indicated. This will require more data points, possibly more accurate measurements and different data analysis such as the transmission exposure curve shown in Fig. 4.

Sincerely,

W. J. Davis

W. J. Davis

WJD/bh

TABLE 1

Film	Date	Slit (microns)	Filter	Squint	Resolution Azimuth/Range	Comments
S21	7- 3-62					Contrast low.
S21D1	7- 3-62					Sent to Westinghouse.
S21D2	7- 3-62					Parts of Run 1, 2, and 4 cut and spliced.
S21CF1	7- 6-62	40	green	rear	none	Only shadows were found.
S21D2CF2	7-18-62	40	green	rear	.005/.025	
S21D2CF3	7-18-62	40	green	front	.005/.025	
S21CF4	7-24-62	12	green	rear	none	Sections of Run 1, 2, and 4 only.
S21D3						For file.
S21D2CF2D1						Sent to Westinghouse.
S21D2CF3D1						Sent to Westinghouse.
S21D2CF2D2						For file.
S21D2CF2D2						For file.
S22						No patterns found.
S22D1						Sent to Westinghouse.
S22D2						For file.

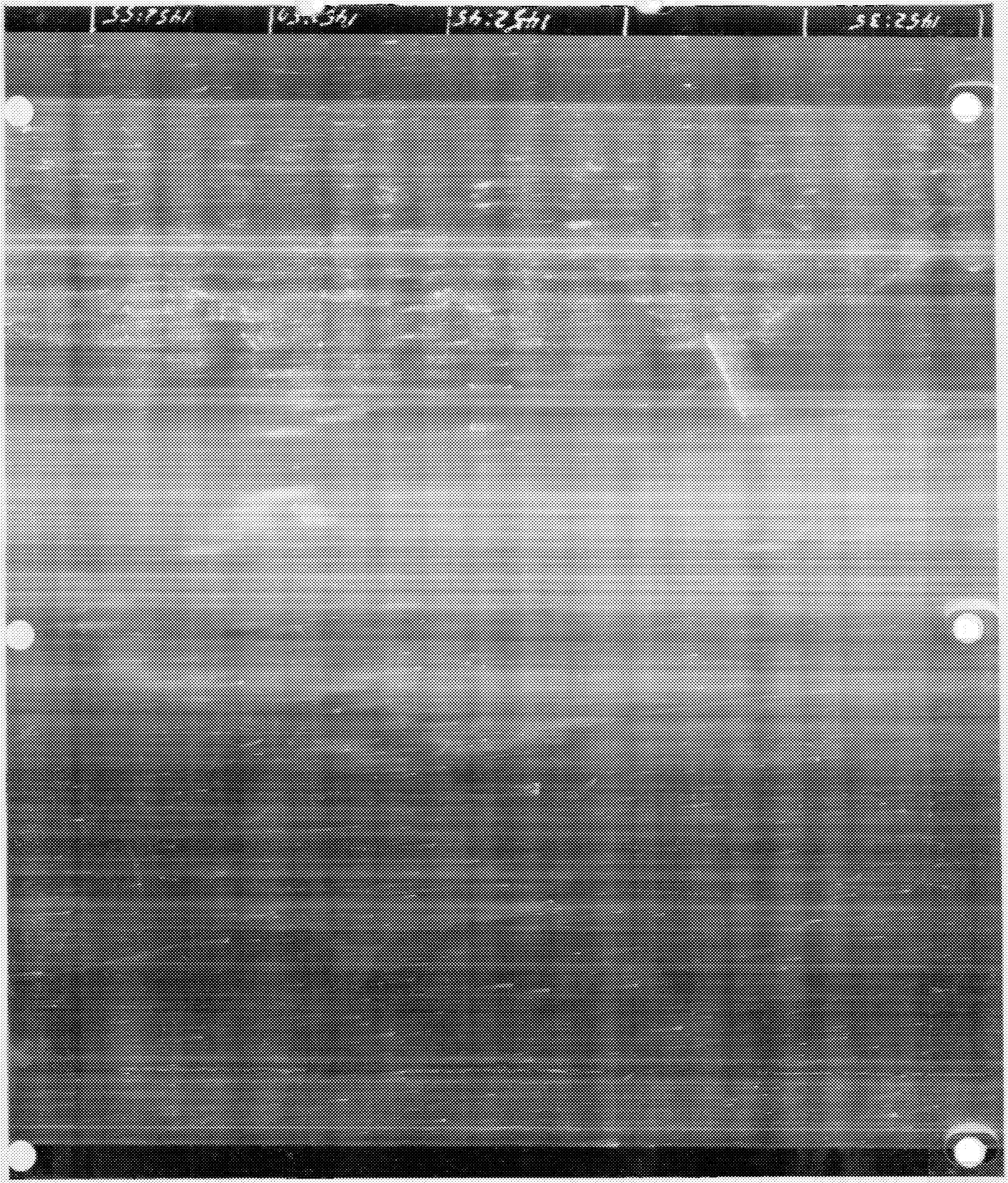


Figure 2

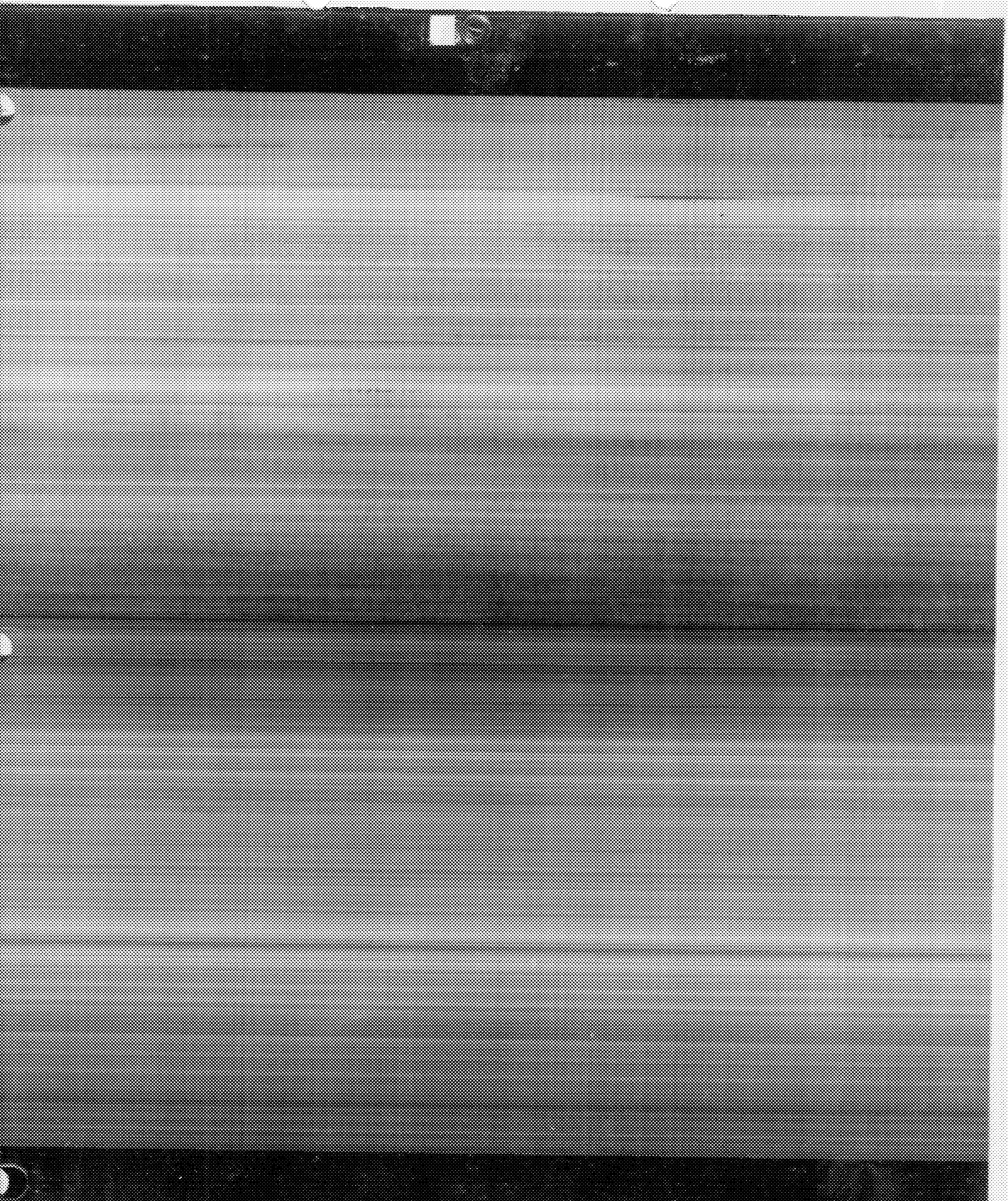
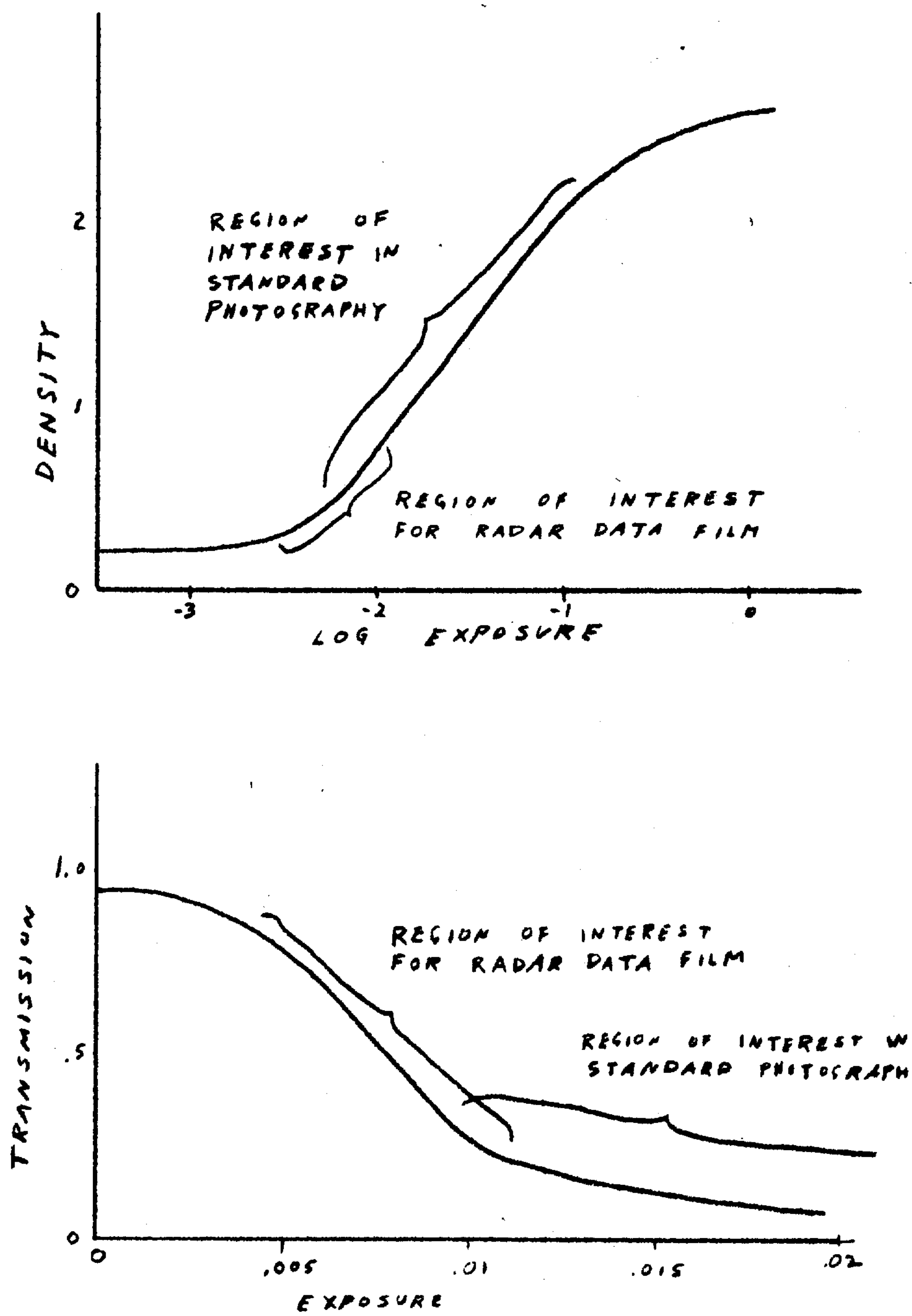


Figure 3



Sensitometric Data Presentation

Figure 4

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19 October 1962

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Processor Progress Report from 1 August 1962 to 1 October 1962

INTRODUCTION

This report covers a two month period. A complete set of the cylindrical lens has not been received. The remaining experimental work has not been completed pending delivery of the lens. Five flight films were received and processed. A large effort has been placed on completing the Handbook and the Final Report.

A verbal go-ahead was received on the optical bench and follow-on to the test and simulation proposal.

TEST AND SIMULATION

Test targets were made in anticipation of receipt of new cylindrical lenses. These targets were 200" and 150" focal lengths similar to test target T115 as described in the April 1962 report.

MODIFICATIONS

The fixed cylindrical lens is due the first week in October. This would complete the cylindrical lens requirement. The interchangeable cylindrical lenses; two (2) from Perkin Elmer and one (1) from Diffraction Limited, have been bench tested and found satisfactory.

Film tracking tests were made and the best results were obtained with edge guides on each side of the liquid platen. Loop control station #3, in the output area, was redesigned and fabricated with a belt system for better tracking.

Because of the necessary increase in recorder film speed, the length of the patterns also increased to approximately 1-1/2". The range compensating wedge interference filters are extremely difficult to make much wider than 3/4" and still maintain the required bandwidth and linearity. The tolerance on bandwidth has been tightened to improve resolution. As a result, new filters were designed to be placed near the output film and will again be fabricated by Spectralab. The first filters are scheduled to be completed by the middle of October.

A new slit, filter holder and microscope assembly has been assembled into the processor as shown in Fig. 1.

FLIGHT TESTS

Flight Film S23: This film was developed August 9th. No patterns were found. This film was not duplicated or correlated. See Fig. 2.

Flight Film S24: This film was developed August 14th. The film was somewhat under-exposed, but did contain a few targets. Visually, the correlation was poor. The processor was realigned, the film was run and the results sent to Westinghouse.

Flight Film S25: This film was developed August 18th. Correlation showed some information. The correlated film was sent to Westinghouse. See Fig. 4.

Flight Film S26: This film was developed August 29th. This was the first film from the lens recorder. The output film showed some ground painting along shorelines and some strong targets. The film was sent to Westinghouse. See Fig. 5.

Flight Film S28: This film was developed September 14th. The results were similar to Flight S26. See Figs. 6 and 7.

OPTICAL BENCH

The major components for the optical bench are in fabrication. It is expected to be ready for use in October.

FINAL REPORT

The first draft on this report is approximately 50% complete.

TABLE #1

Film	Date	Filter	Dot Size Azimuth/Range	Remarks
S23	8- 8-62			Very light, not correlated or duplicated.
S24	8-13-62			Information good, but much appears out of focus.
S24D1	8-15-62			Sent to Westinghouse.
S24D2	8-15-62			For File.
S24CF1	8-21-62	green		Sent to Westinghouse.
S25	8-17-62			Little information.
S25D1	8-20-62			Sent to Westinghouse.
S25D2	8-20-62			For File.
S25CF1	8-21-62	green		Sent to Westinghouse.
S26	8-28-62			Some information, good density.
S26D1	8-29-62			Sent to Westinghouse.
S26D2	8-29-62			For File.
S26CF1	8-30-62	green		Sent to Westinghouse.
S28	9-14-62			Small areas of information (far range out of slit)
S28D1	9-17-62			Sent to Westinghouse.
S28D2	9-17-62			For File.
S28CN1	9-18-62	green	.004/.010	Only one fair area.

SPECIAL HANDLING

HANDBOOK

The major portion of the handbook has been written. Some re-writing to update the handbook is required.

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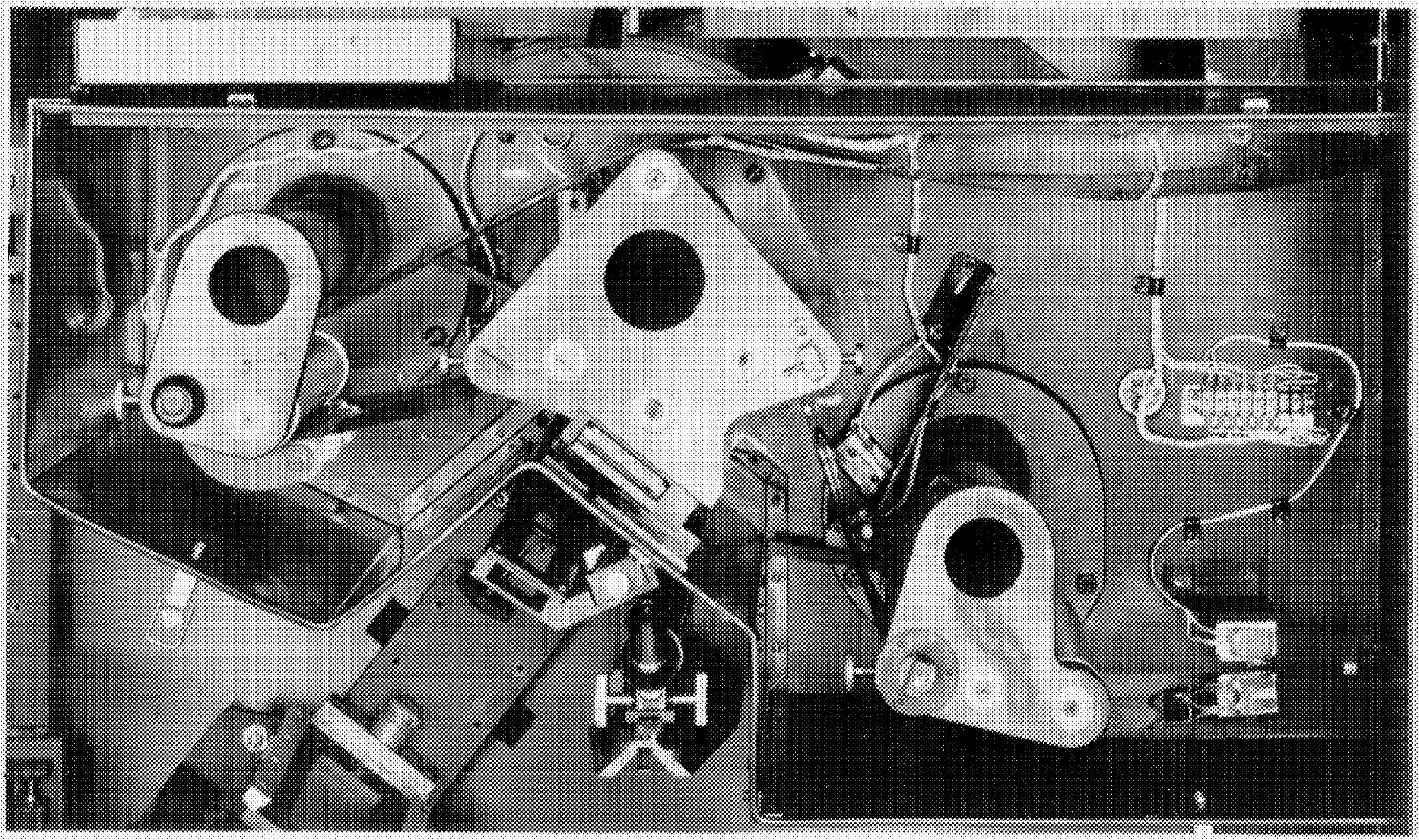
SPECIAL HANDLING



Output Area Showing New Slit and Filter Holder

Figure 1

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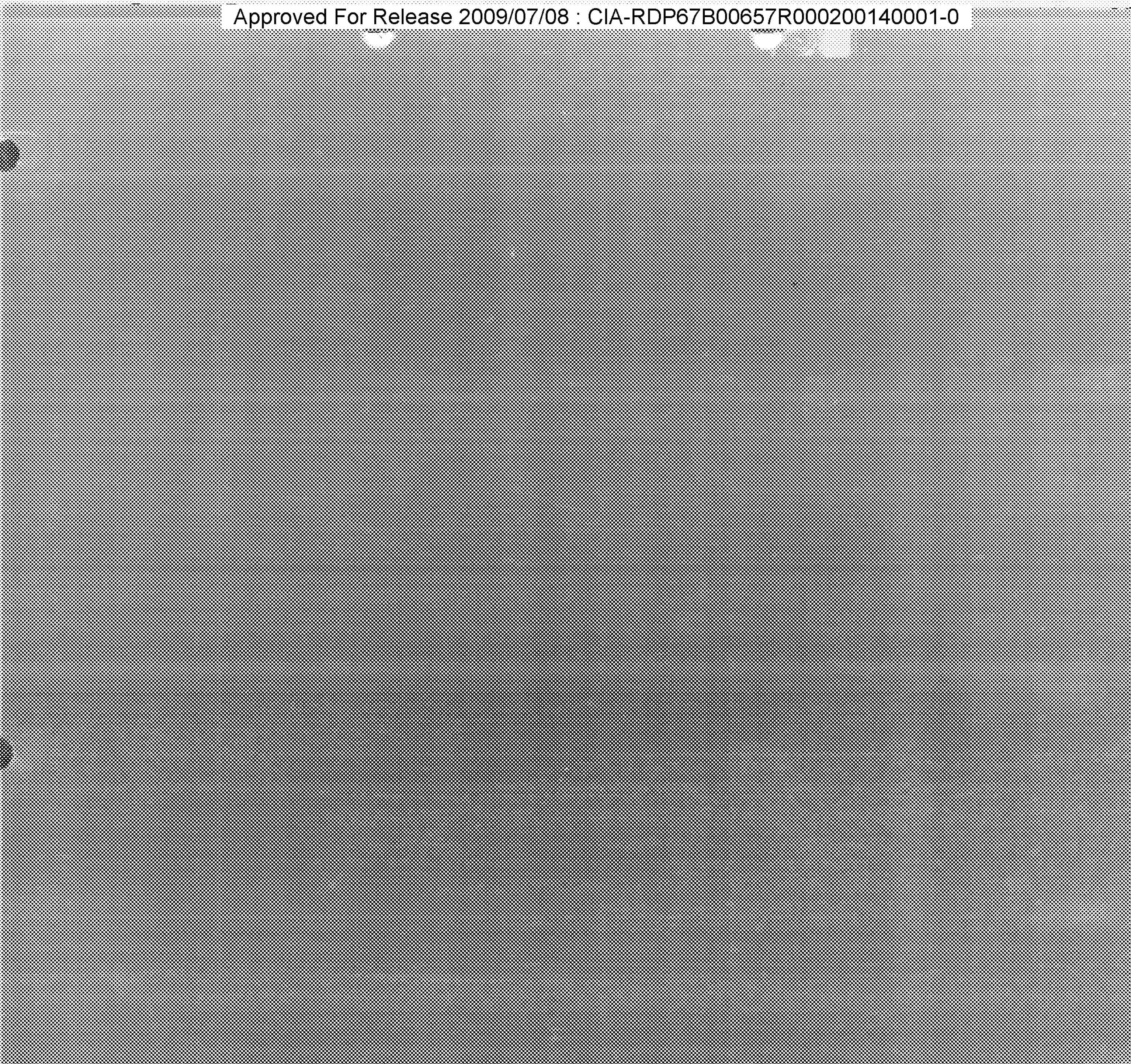

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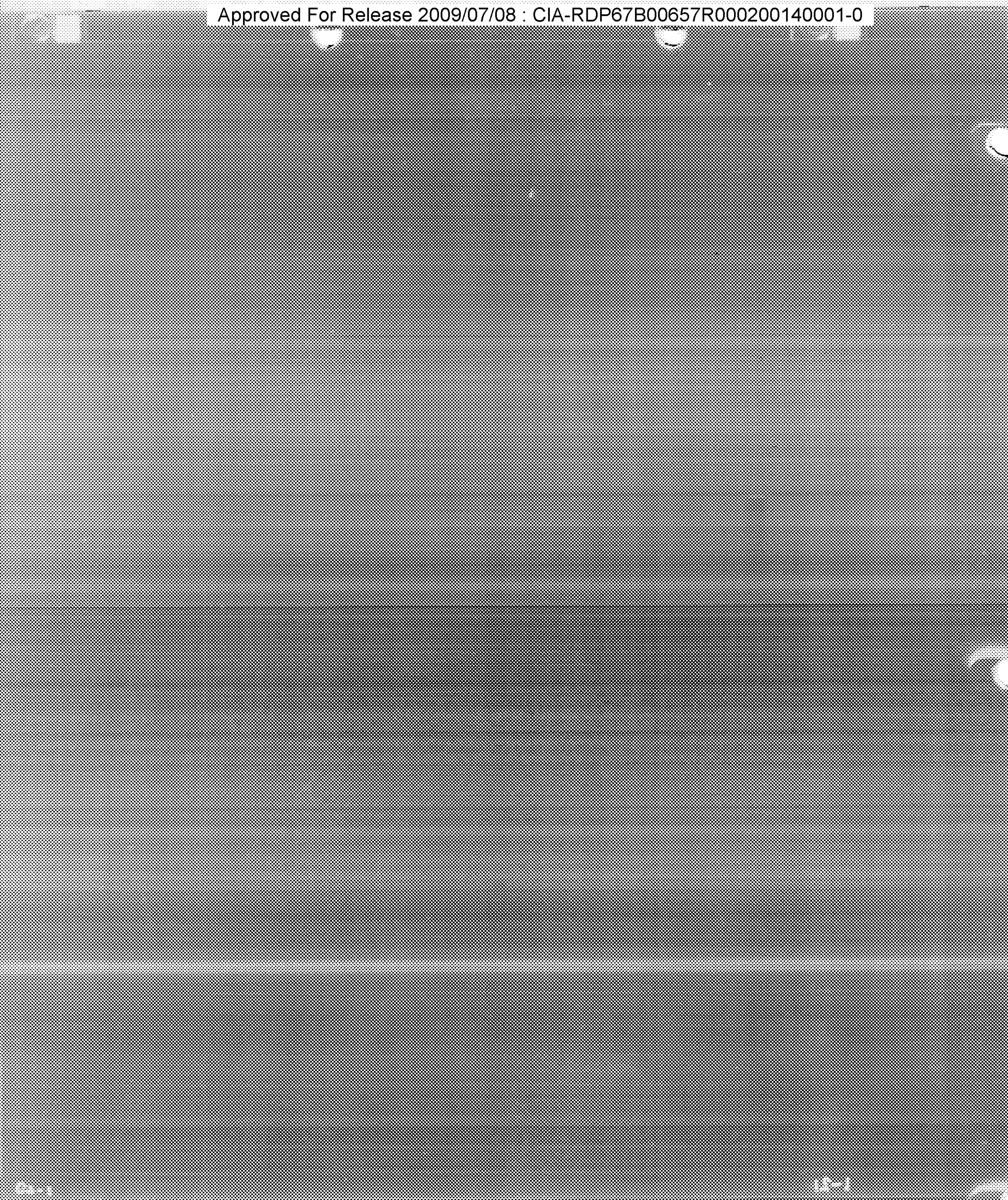

Figure 4

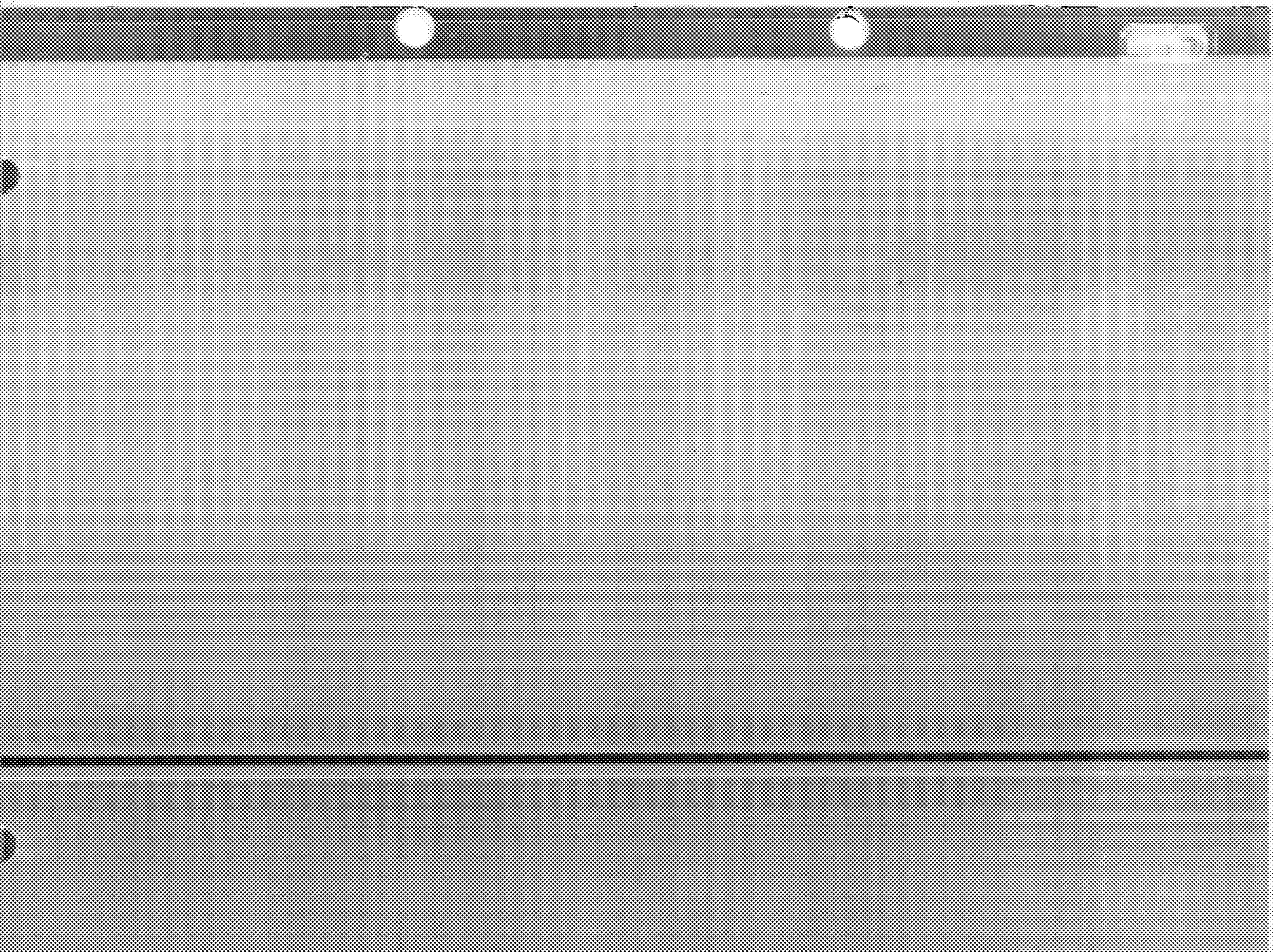

Figure 5

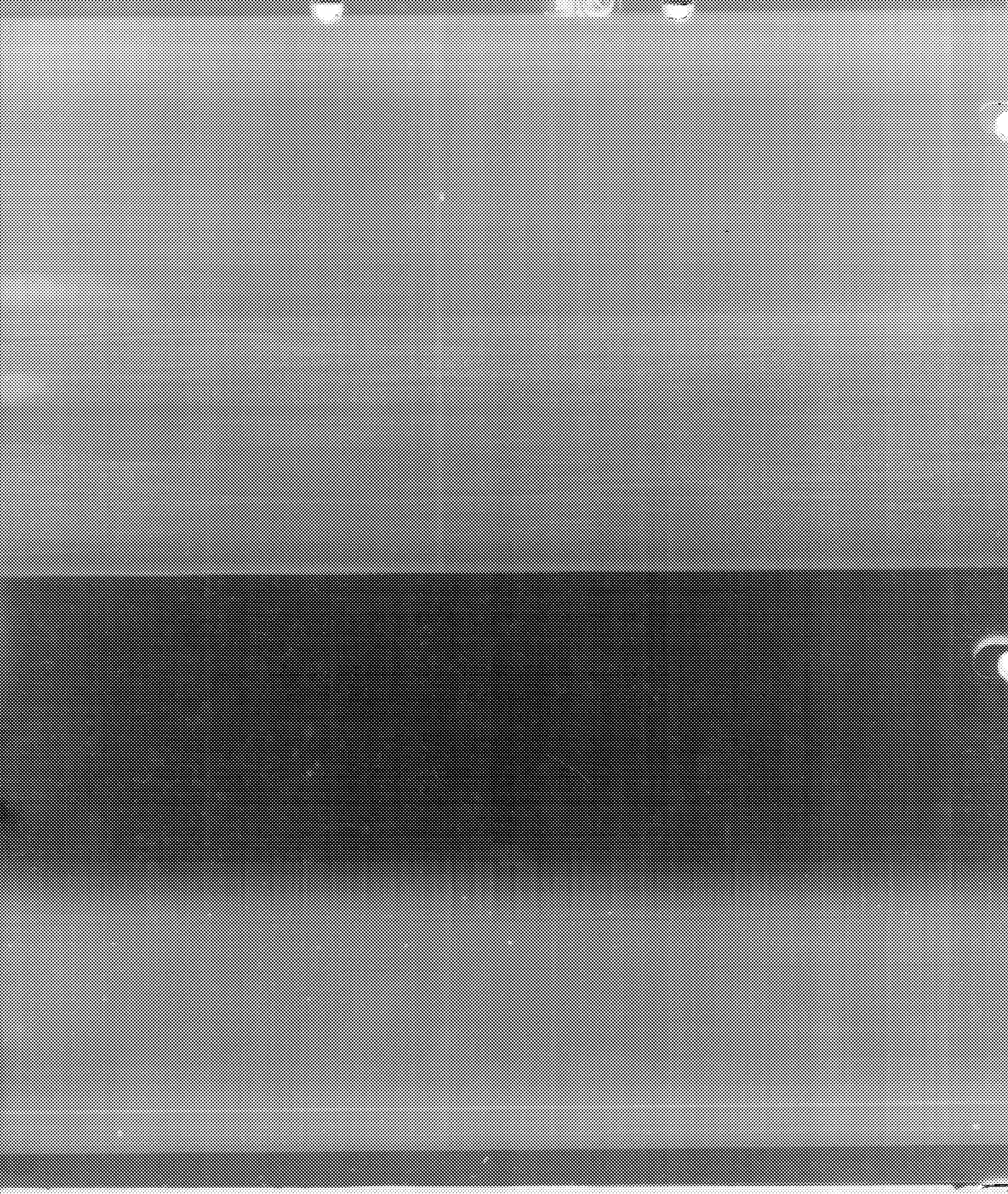

Figure 6

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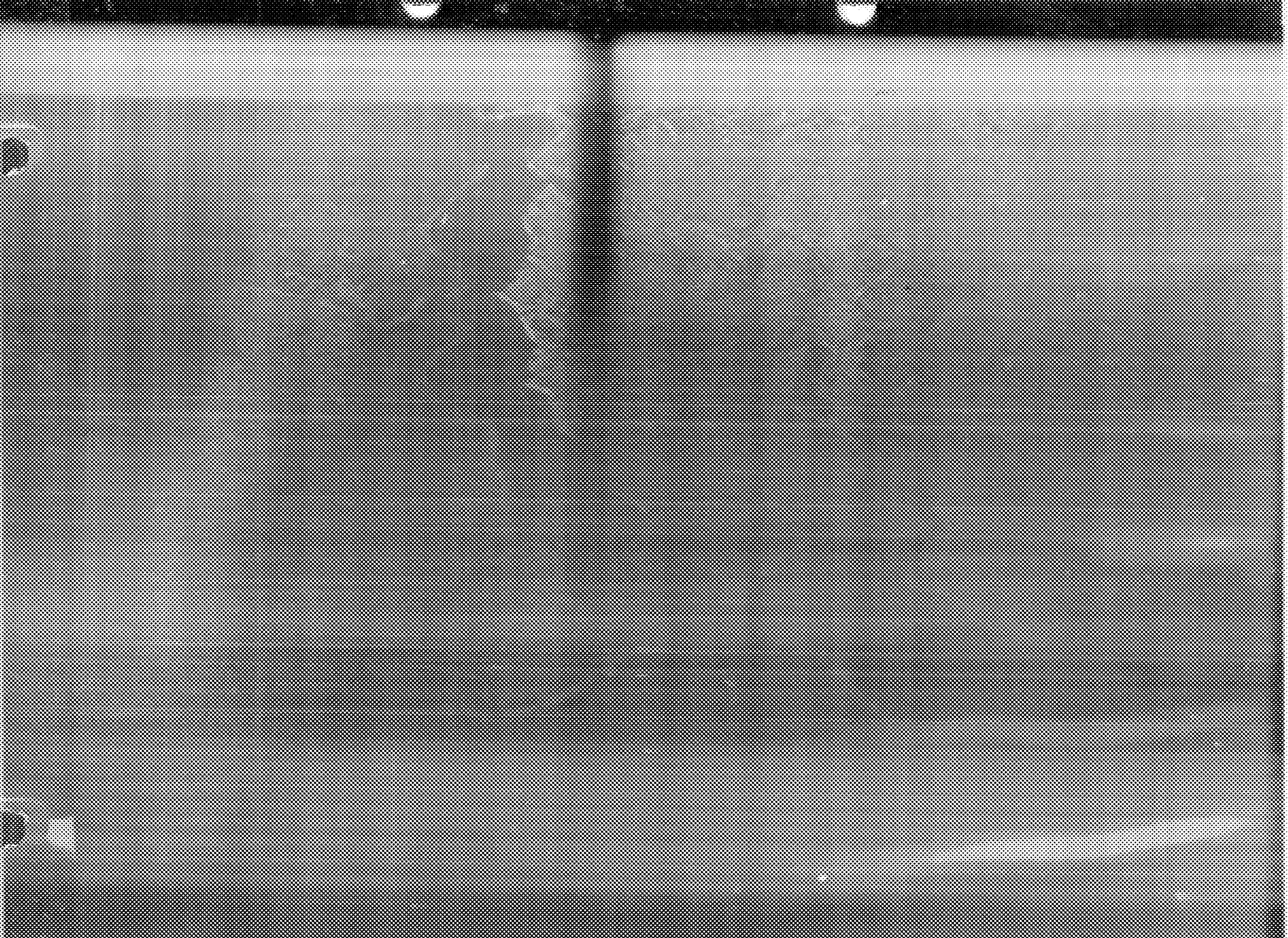

Figure 7

SPECIAL HANDLING

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16 November 1962

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Processor Progress Report from 1 October 1962 to 1 November 1962

Introduction

Cylindrical lenses have been received. Three flight films were received and processed. Second draft of the handbook has been completed. The optical bench has been partially completed. Some tests have been made on the bench.

Modifications

The fixed cylindrical lens was received. This completed the cylindrical lens requirements. The lenses were installed and the correlator realigned.

A new liquid platen is in the design stage. The original design was hampered by the wedge filter that was in close proximity. This has been removed and now allows greater freedom for the liquid platen.

Test and Simulation

With the new cylindrical lenses installed, man-made targets were run and we were able to readout 2.5 mils which is close to the theoretical limit.

Film S-11 was re-run to see what improvements could be noted, now that the correlator had been realigned. No measurable improvement in the output was seen. All of the available information available on the film had been obtained during previous runs.

Flight Tests

Flight Film S-29 was received and developed October 10, 1962. The film had good exposure with the best information in Run 3. (See Fig. 1)

SPECIAL HANDLING

TABLE 1

Film	Date	Filter	Slit*	Comments
S29	10- 9-62			Exposure reasonable, good information mostly in Run 3.
S29D1	10-10-62			Sent to Westinghouse.
S29D2	10-10-62			For File.
S29CF1	10-13-62	wedge	4	Fluid ran dry — underexposed.
S29CF2	10-17-62	green	4	Underexposed.
S11CF17	10-18-62	green	4	Underexposed.
S11CF18	10-19-62	green	7	Good line and dot widths, i.e. approximately .002-.003.
S30	10-23-62			Good, some of highest density than previous runs — marked S-30 run 4 partially out of slit, some parts out of focus.
S30D1	10-24-62			Sent to Westinghouse.
S30D2	10-24-62			For File.
S30CF1	10-24-62	green	7	Run with slit at 3 for ten minutes, this was only part of the film not too dark. Zero order passed thru.
S30CF2				
S30CF2	10-25-62	green	7	Good correlation — Run 4 lost due to loop 3 belts off of rollers.
S30CF3	10-26-62	green	7	Good correlation.
S30CF3D1	10-26-62			Sent to Westinghouse.
S31	10-26-62			Looked very noisy. Not correlated.
S31D1	10-29-62			Sent to Westinghouse.
S31D2	10-29-62			For File.

*Slit calibration not known.

The film was correlated with both a wedge filter and a green filter (see Fig. 2).

Flight Film S-30 was received and developed October 24, 1962. This film had more contrast than previous ones. The third and fourth runs were partially out of the slit. There were areas that were out of focus and yet contained correlatable patterns close-by (see Figs. 3 and 4).

Flight Film S-31 was received and developed October 29, 1962. The information was not continuous and the film was not correlated (see Fig. 4).

Optical Bench

The bench has been partially assembled. The liquid platen, the microscope and camera assemblies are under construction. An assembly to handle $9\frac{1}{2}$"roll film as been designed, and will be ready for fabrication early next month.

The bench has been used to run various tests. Furthermore, the principle of the area correlator has been successfully demonstrated on the bench.

Handbook and the Final Report

The second draft of the processor handbook has been completed. This draft will be put into its final form during the next report period. No effort has been spent on the final report during the past month.

System Analysis

During the past month a number of tests have been conducted in an effort to determine the recorder-correlator system performance. A swept-frequency generator has been devised to produce linearly varying frequencies in the recorder. The focal lengths of the resulting zone plates were measured on the optical bench and the frequency ramp helipot settings were calibrated to read focal length directly. Patterns of a wide variety of focal lengths have been produced, and include up to 1500 cycles.

It was anticipated that there might be some phase errors in the patterns, especially at the lower frequencies, because of the nature of the generator circuit. To check this, a hand-ruled master pattern and a recorded pattern with the same focal length were both enlarged to the same scale of approximately 5X. A paper print was made of the enlarged recorded pattern and a transparency of the ruled master. When the two photographs were superimposed the resulting Moiré fringes indeed showed where phase errors existed and where pattern coherency was good.

A set of patterns, which consisted of some 125 discrete "range" channels over a 4 inch trace, was generated on the recorder and placed in the correlator. The patterns varied in focal length from 125 to 175 inches in 5 inch increments. Thus, for example, a whole group of 125 individual zone plates, each with a focal length of, say, 175 inches could be examined and a measure of the system image quality could be made.

It was found on visual examination, that the resulting correlated images were between 0.0035" and 0.004" wide. Background noise, apparently caused by irregularities in the patterns, was largely eliminated by either masking off the patterns themselves or by closing down the spatial filter. It should be noted that the image size remained about the same until less than a quarter of an inch of aperture was left. At this point the image "blew up" and became unusable. The same effect occurred when the spatial filter was stopped down.

A photographic run was made using these patterns and monochromatic green light from a 5461 Å interference filter. The spatial filter was narrowed to about 1/16" or slightly less, corresponding to a pass band of between approximately 7 and 35 cycles on the pattern. This was equivalent to putting a mask about 1/4 inch wide in the input platen. The images produced on film were examined and it was found that all focal lengths between 140" and 175" produced approximately the same size image of 0.004 to 0.005 inches. At 125" the image width was about 0.008". That the image size varies so little is not surprising when the relative aperture of the system as used is considered. A pattern with a 150" focal length, stopped down to 1/4 inch, is in effect, an f/600 "lens." After undergoing slightly more than a 4X reduction in azimuth in the correlator the output f/no. is only on the order of f/150. Using the criterion of Focal Range = $4\lambda(f/no)^2$,

$$\begin{aligned}
\text{with } \lambda &= .5 \times 10^{-3}\text{mm} \\
f/no. &= f/150 \\
\text{F.R.} &= 4 \times 0.5 \times 10^{-3} \times (150)^2 \\
&= 20 \times 10^{-4} \times 2.25 \times 10^4 \\
&= 45 \text{ mm} \\
\text{or } &\pm 22\tfrac{1}{2} \text{ mm.}
\end{aligned}$$

Thus, the focal length can change considerably before there is much degradation in image quality in monochromatic light. The same situation is apparently also true of the flight test film. An enlarged print (see Fig. 6) of a section of a flight test film, when compared to a ruled master, shows this. It would appear that only a portion of the aperture is usable, perhaps about 1/4", because of platform instability, vibration, CRT trace excursions or other anomalies. The spot size, then cannot be much smaller than 0.004" unless a larger useful aperture is available.

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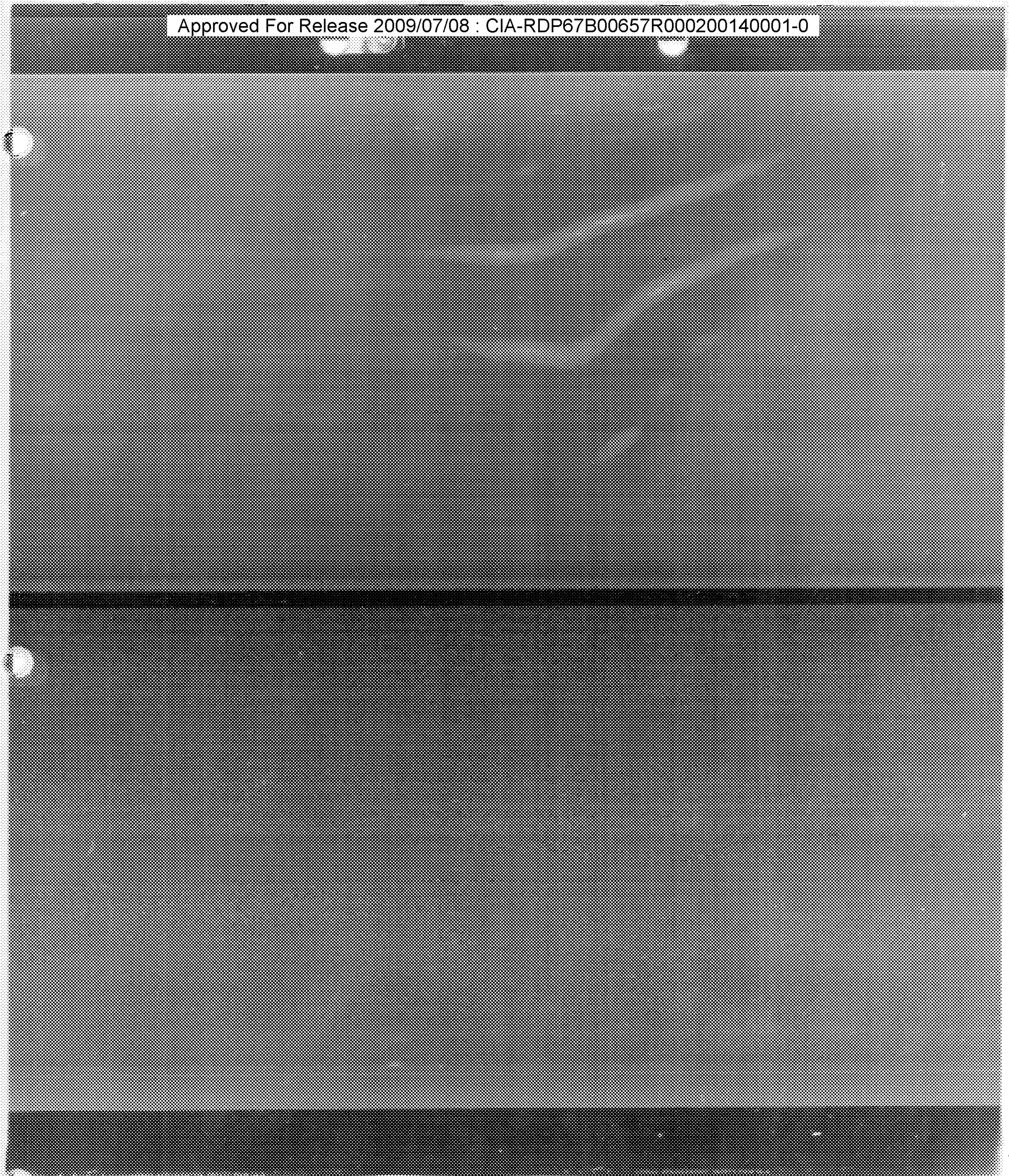

Figure 1

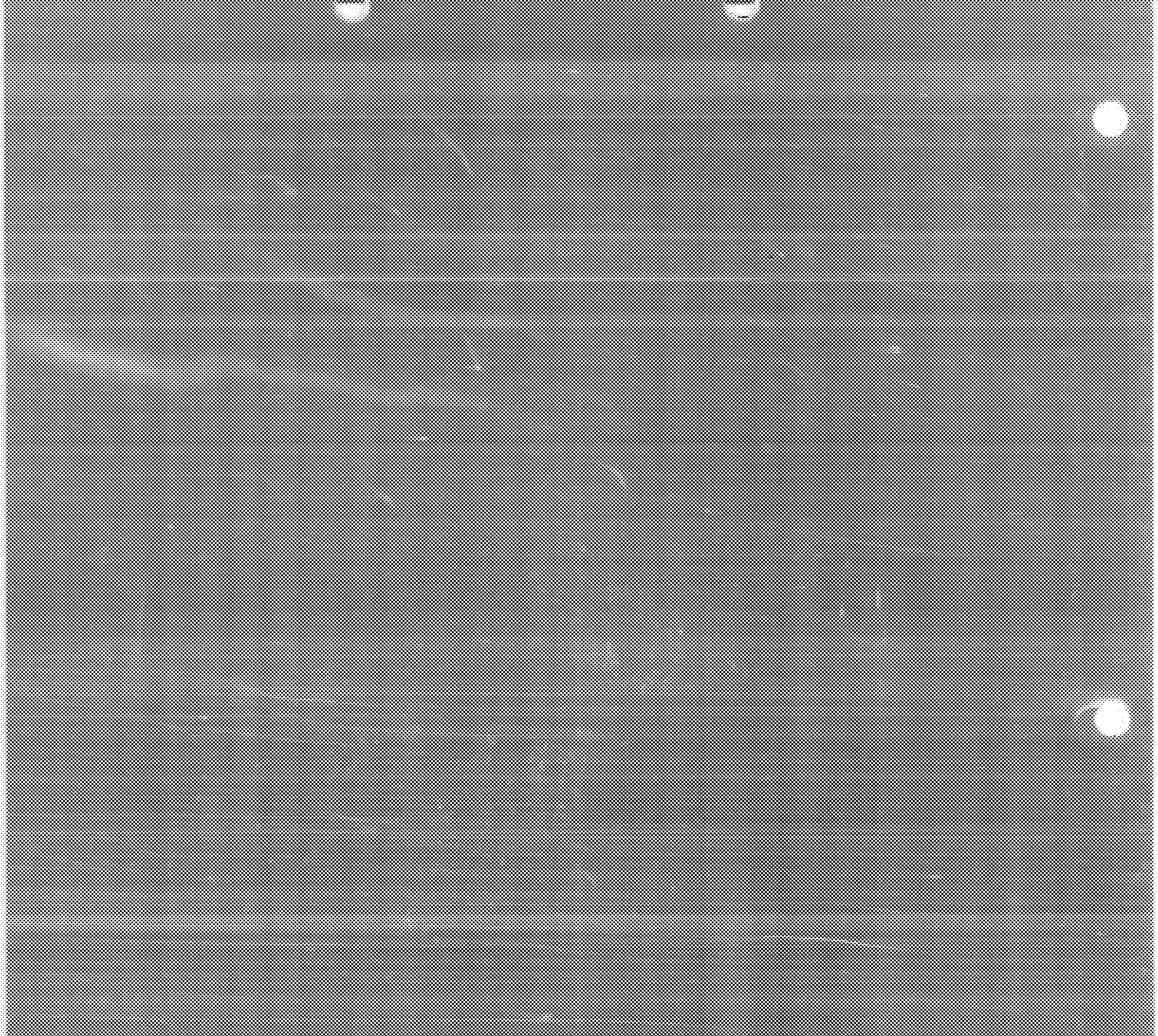

Figure 2

Figure 3

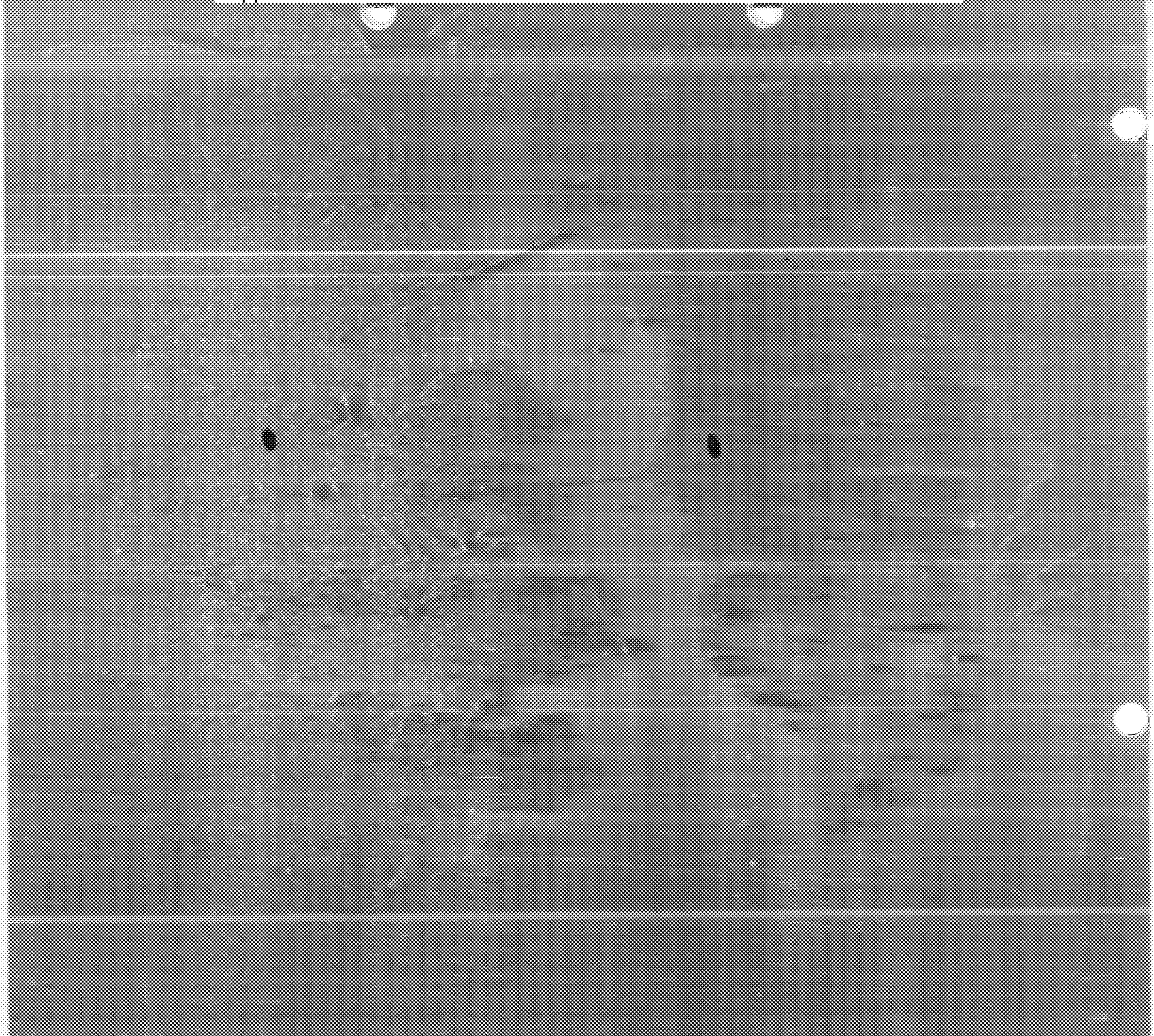

Figure 4

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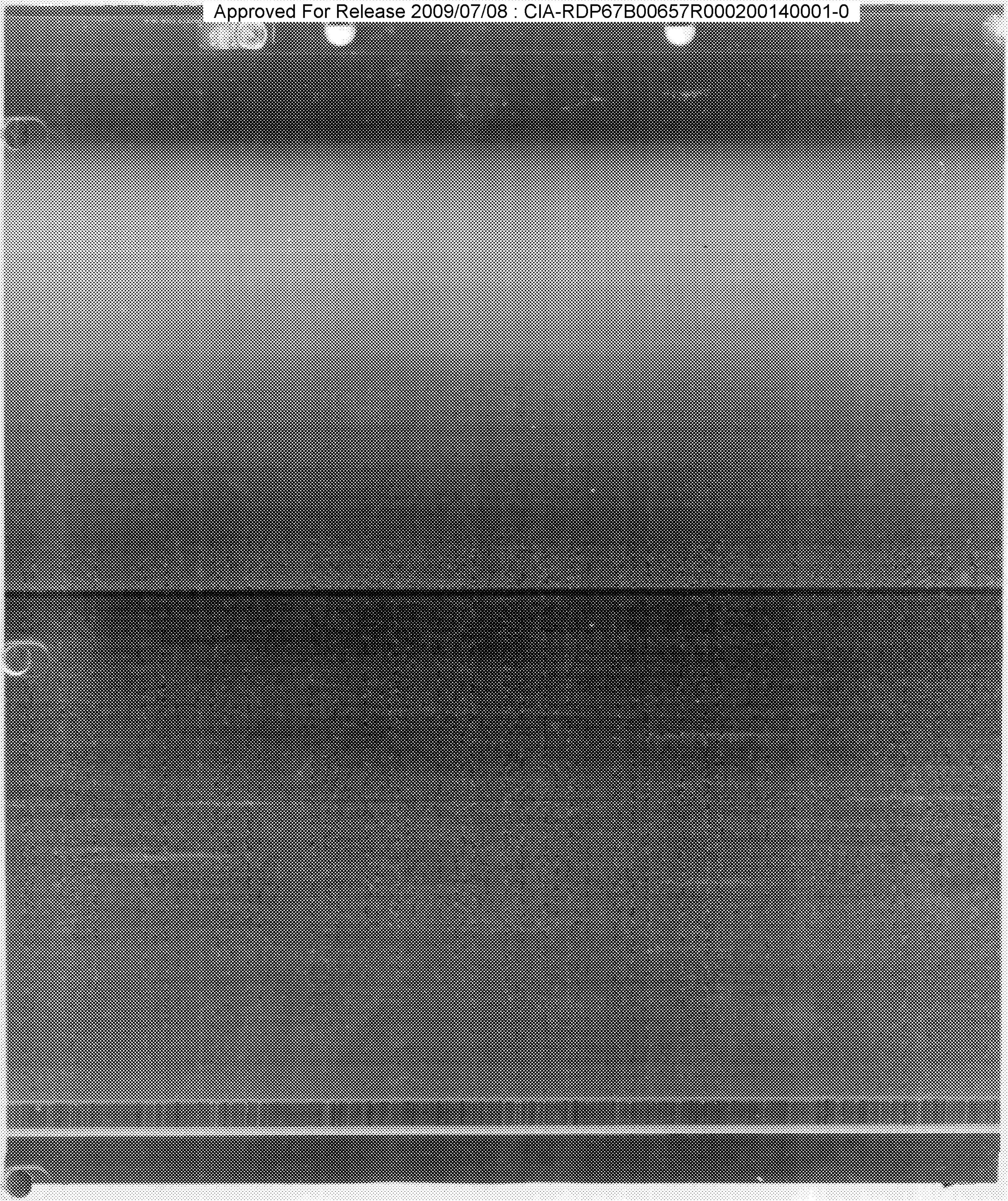

Figure 5

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Processor Project Report from 1 November 1962 to 1 December 1962

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Test and Simulation

Preliminary runs for determining the effect of aperture size and aperture shift were made. A series of single line patterns were used at the input. The narrowest images were obtained as the aperture was shifted toward the high frequency end of the pattern, but since the exposure also decreased, much of any improvement was caused by this. The minimum line image width was .003 ", or about 28 ft. ground distance.

The overlapped pair pattern (T115) was run several times to determine the best resolution and target separation. It was found that with slit sidths ranging from 6 to 15 microns that input separation of .012 or output separation of .0027 could be resolved.

Flight Films

Flight Film S-33 was received, developed and duplicated on November 20, 1962. First observation showed little information except in the third run (see Fig. 1). Subsequent processing however, showed the other three runs did contain much information. Resolution and detail on this film was the best received thus far (Fig. 2).

Film	Date	slit width (microns)	Filter	Resolution azimuth	Remarks
S33	11-20				Run 3 best, with good contrast. Information.
S33D1	11-20				Sent to Westinghouse.
S33D2	11-20				For File.
S33CF1	11-20	42	green	.002-.003	Good.
S33CF2	11-26	42	green	.002-.003	Good.
S33CF3	11-28	42	5" wedge at output	.002-.003	Range resolution seemed slightly better than previous runs.

Optical Bench

The optical bench, as originally conceived, is essentially complete (see Fig. 3-8). The liquid platen, microscope, camera assemblies and $9\frac{1}{2}$ inch roll film assembly are complete. A photomultiplier scanner and recording chart are being made for measuring the intensity of images or modulation in the diffraction pattern. All flight film is now being examined on the bench visually and photographically to determine where possible the frequency and noise content of the film. The scanner, when available, will be used to make quantitative measurements of the energy distribution.

Some of the effects of vibration in the recorder system have been examined on the optical bench. A swept frequency generator was used to produce a pattern of a nominal focal length. Then, 50 cycle sinusoidal and square wave jitter of varying amplitude was introduced in the swept frequency. This had the effect of physically moving the CRT trace back and forth or vibrating the recorder optics, the mirrors in particular.

The pattern with no jitter (Fig. 9 A) was focused, using the bench optics and spatial filter, into a single line (Fig. 10). This line has some side structure due to nonlinearities in the sweep circuit, but serves to illustrate the effect. With the maximum amplitude square wave jitter applied to the sweep (Fig. 9 B), the image is broken up into a number of lines (Fig.11), all of which still appeared to be in focus. This also occurred, in varying amounts, at the other amplitudes of sinusoidal jitter. Thus, the introduction of periodic vibration frequencies can introduce ghosts or false spectrum lines in much the same fashion as a periodic error in the lead screw of a diffraction grating ruling engine. Since each grating (i.e. zone plate) is in effect generated slightly differently each time, the ghosts will appear somewhat differently each time.

In conjunction with this phenomenon, it was postulated that under certain conditions it might be possible for one half of a pattern to be exactly 180° out of phase with the other half. This situation should then produce cancellation of the image, or zero intensity, assuming among other things that the modulation in the two halves were equal. If this were not the case then it would be expected that some intensity diminution would still take place.

A ruled positive pattern, with a focal length of 150" was contact printed on film to produce a similar negative. When properly superimposed, the resulting Moiré fringes go to zero and light transmission is at a minimum. Now, if the patterns are turned so that the high frequencies of one extends in a direction from the zero frequency opposite that of the other pattern (Fig. 12), the image cancellation effect should be seen. The patterns were separated at first so that two images were seen (Fig. 13A). Then, as the patterns were pushed together, so that the images merged into one, it was found that the intensity actually increased instead of decreased (Fig. 13B). Whether or not it was a straight arithmetical addition of intensity is not known, although this will be determined with the scanner.

It should be noted that this experiment was not done with the use of a liquid gate, without which it is probably impossible ever to get cancellation, because the two halves of the patterns were not, apparently, coherent with each other. This test will be run again with the liquid platen which is now available, but there is still some question as to whether this cancellation can actually be achieved in practice.

Liquid Platen

On the correlated photos of flight test film S-33, the effect of minute scratches on the input film are apparent. This is caused by the slight mismatch in index of refraction of the film ($n = 1.478$) and tetrachloroethylene ($n = 1.504$). That this effect did not manifest itself prior to now is apparently due to the fact that on this film the low spatial frequency cutoff filter was set much closer to zero than ever before. Light refracted or scattered from the scratches evidently is deviated close to the low pass cutoff, but slightly beyond so that heavier exposures are made on the output film in the form of streaks. The index match can be made exact by the addition of a lower index fluid such as methyl chloroform.

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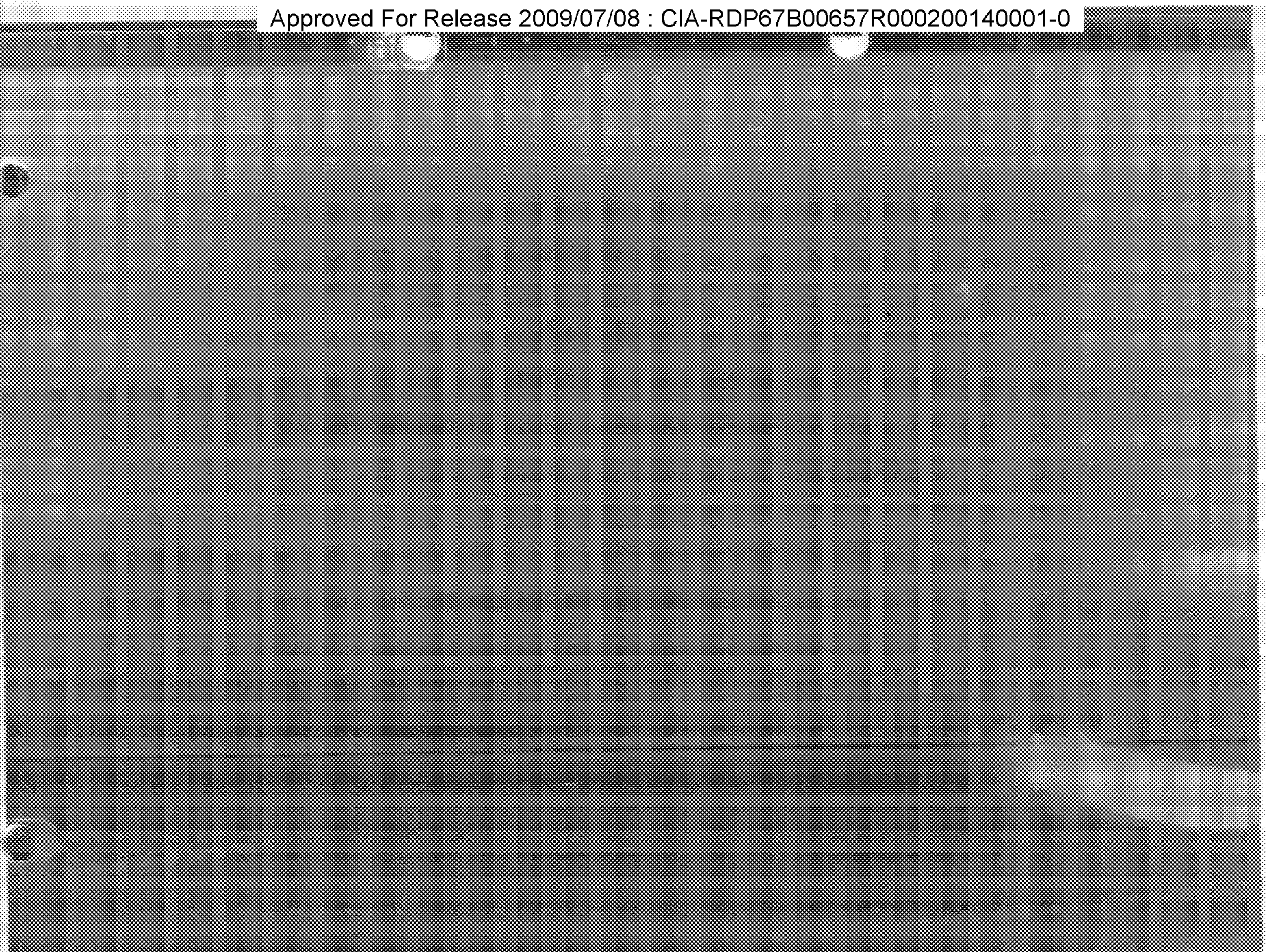

Figure 1

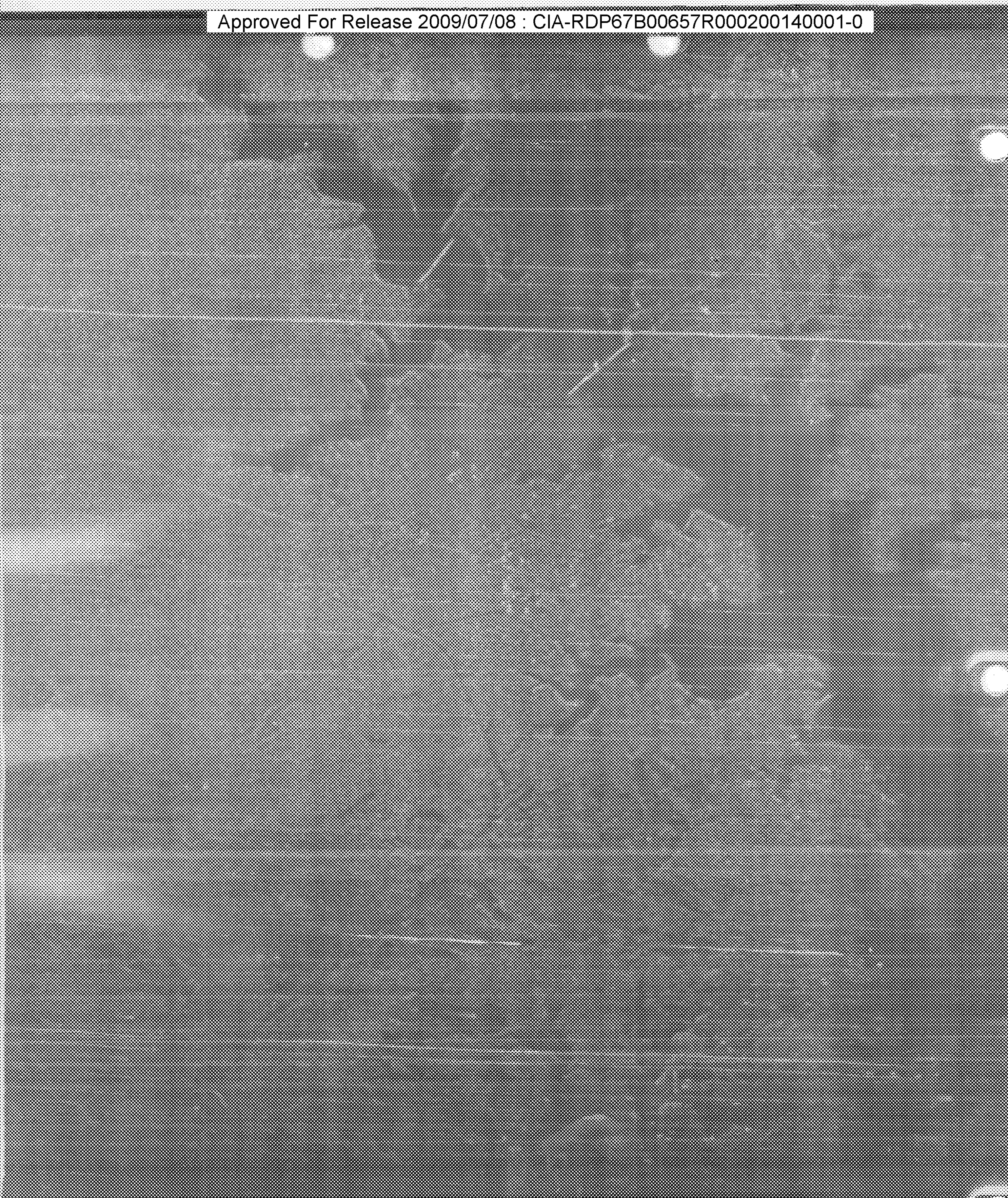

Figure 2

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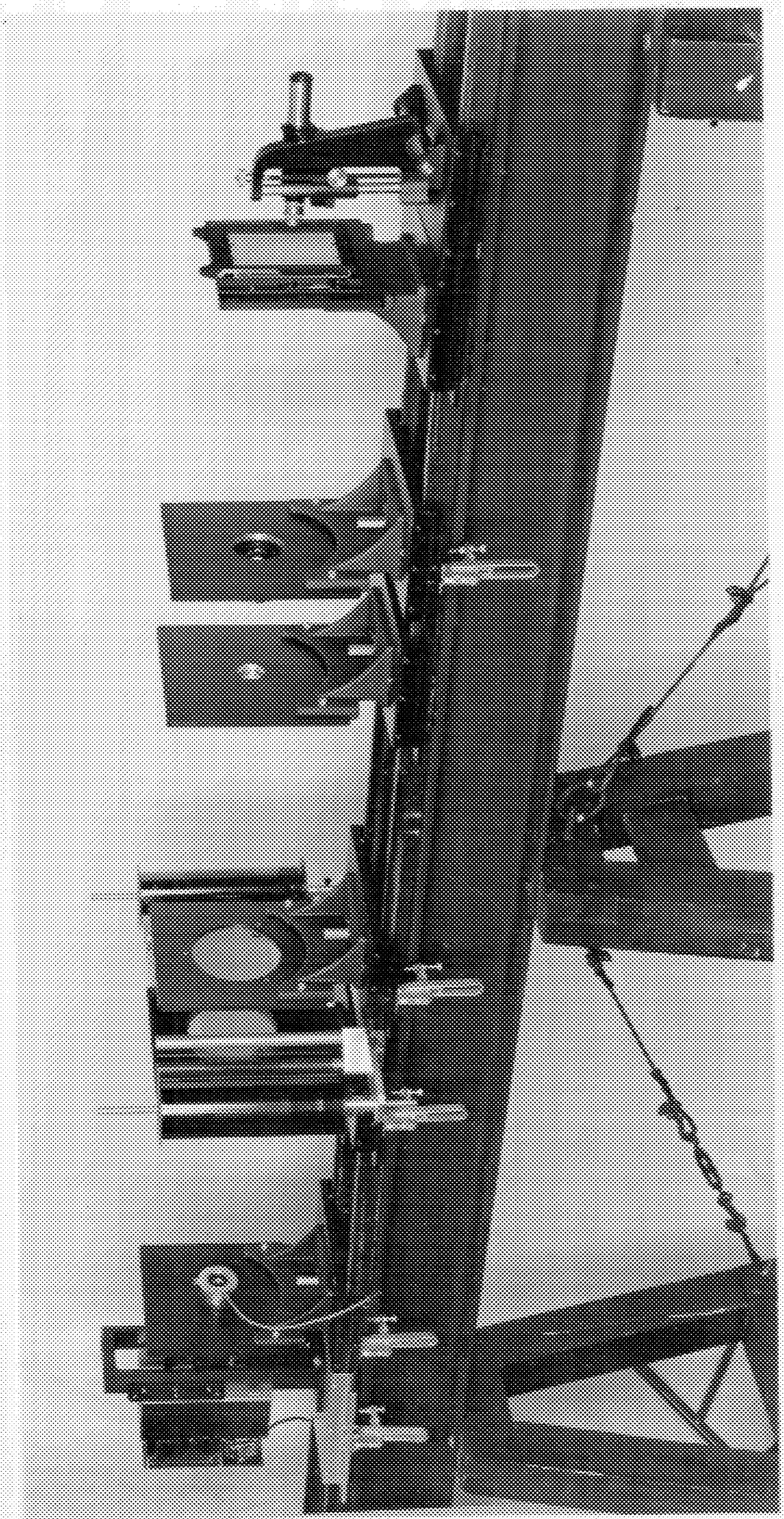


Figure 3

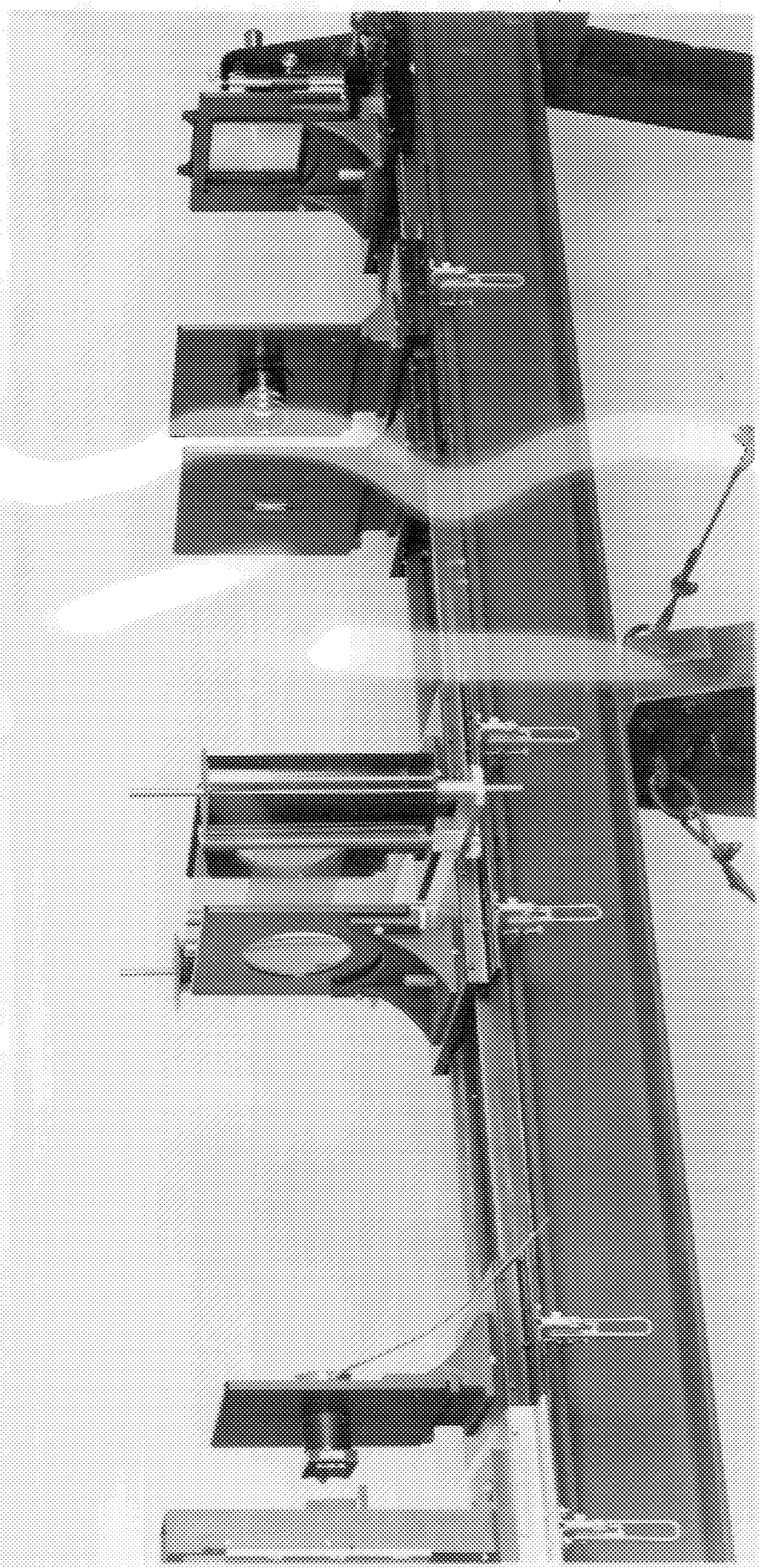


Figure 4

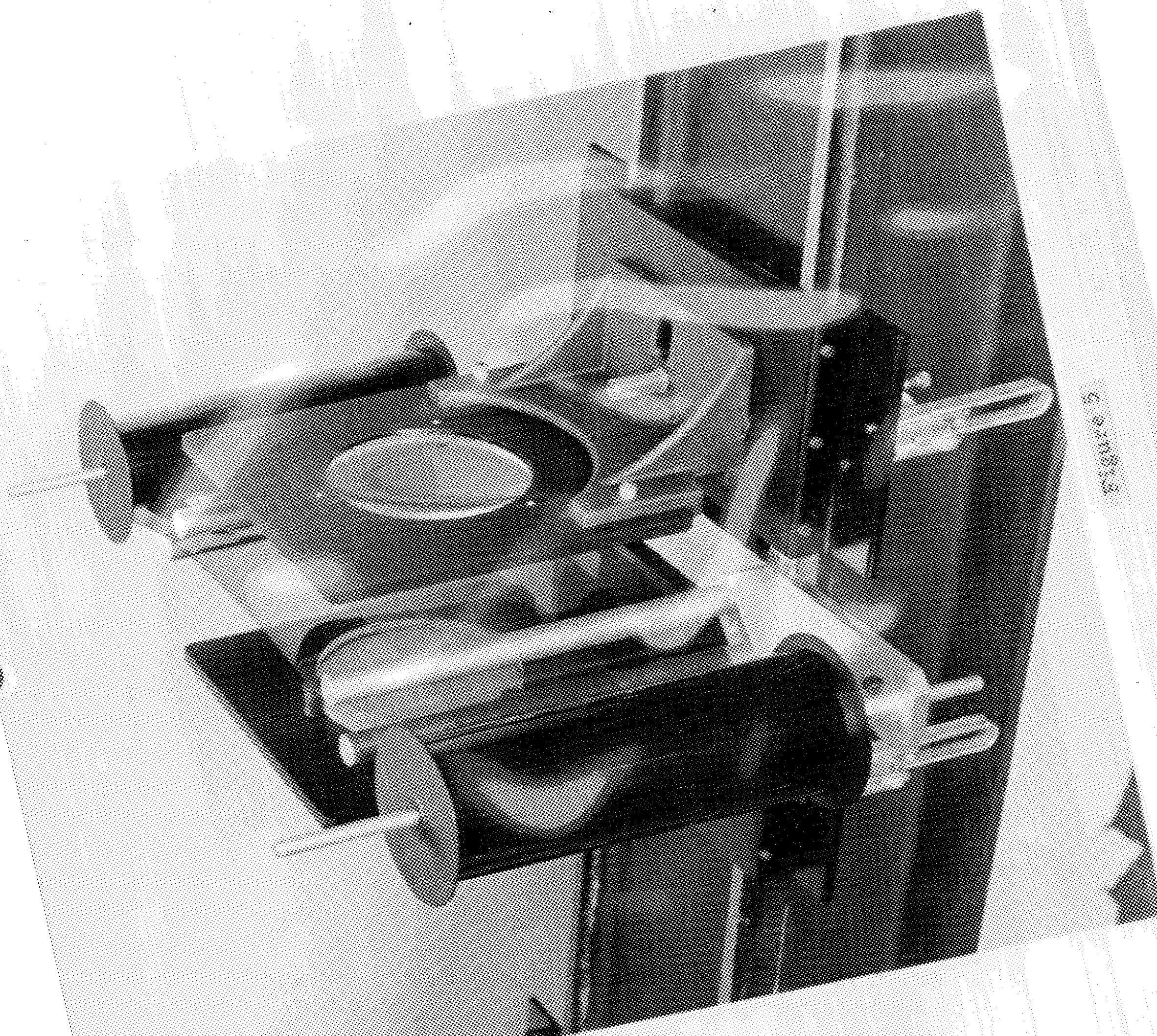
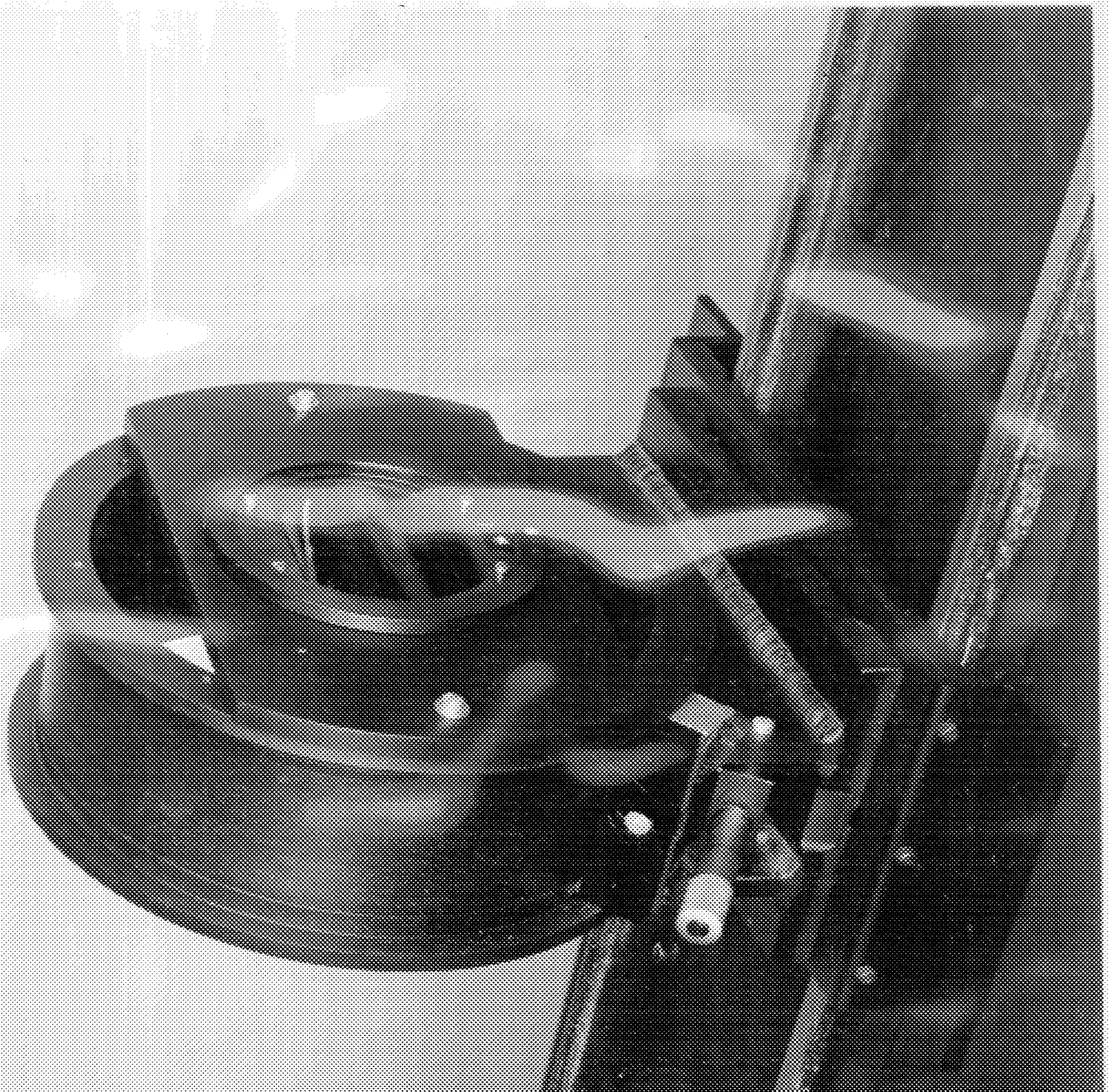


Figure 9



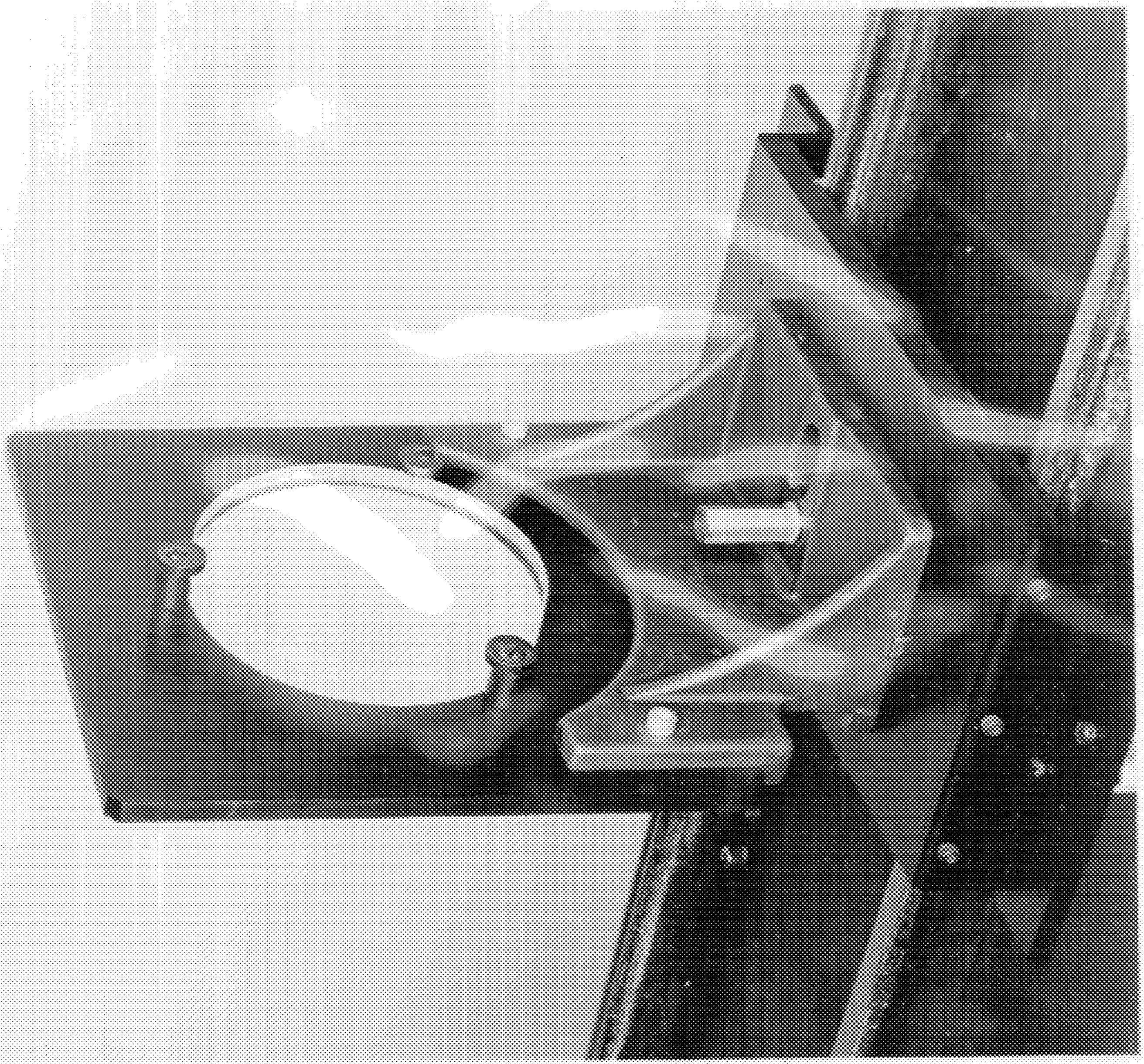
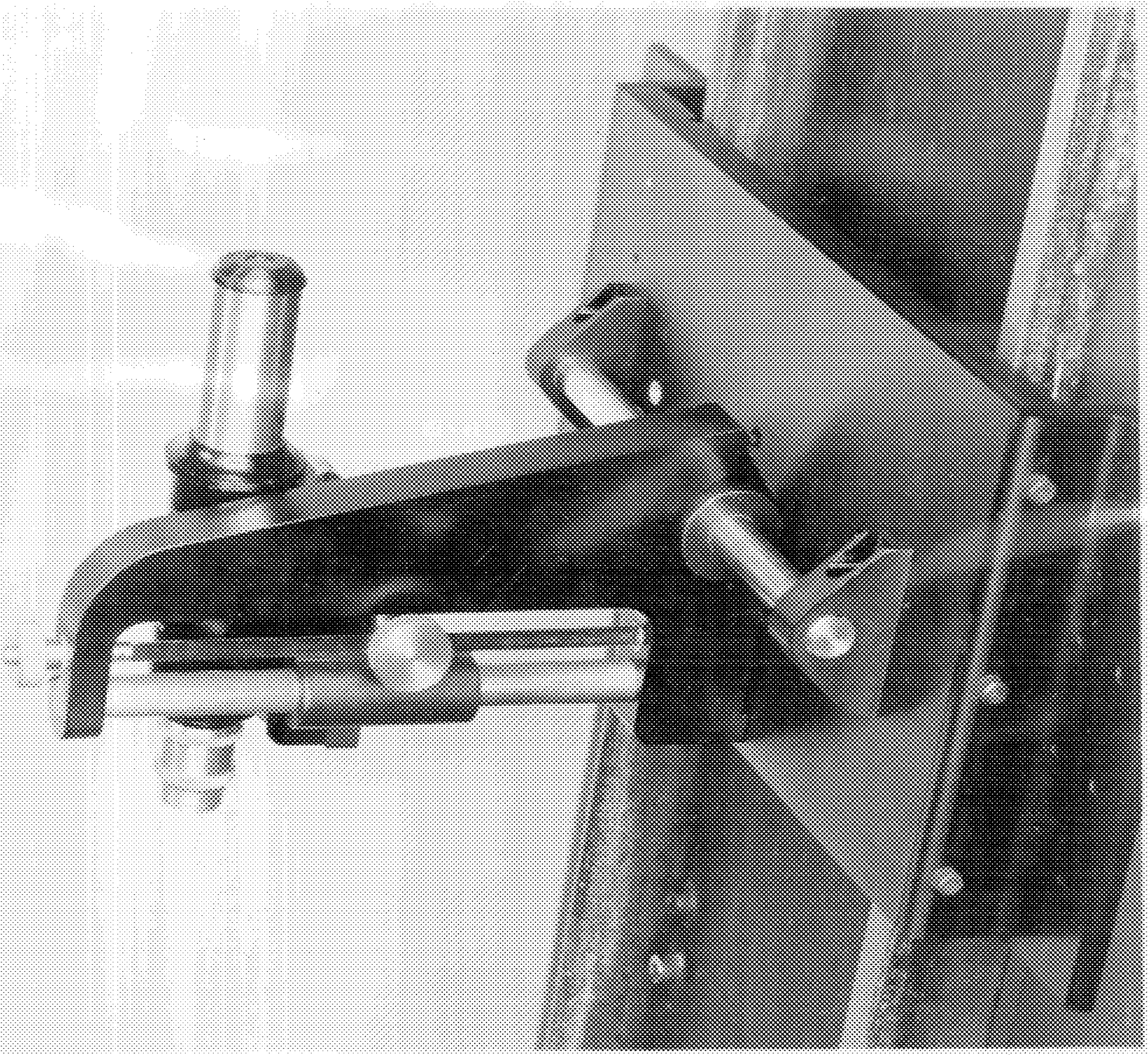


Figure 7



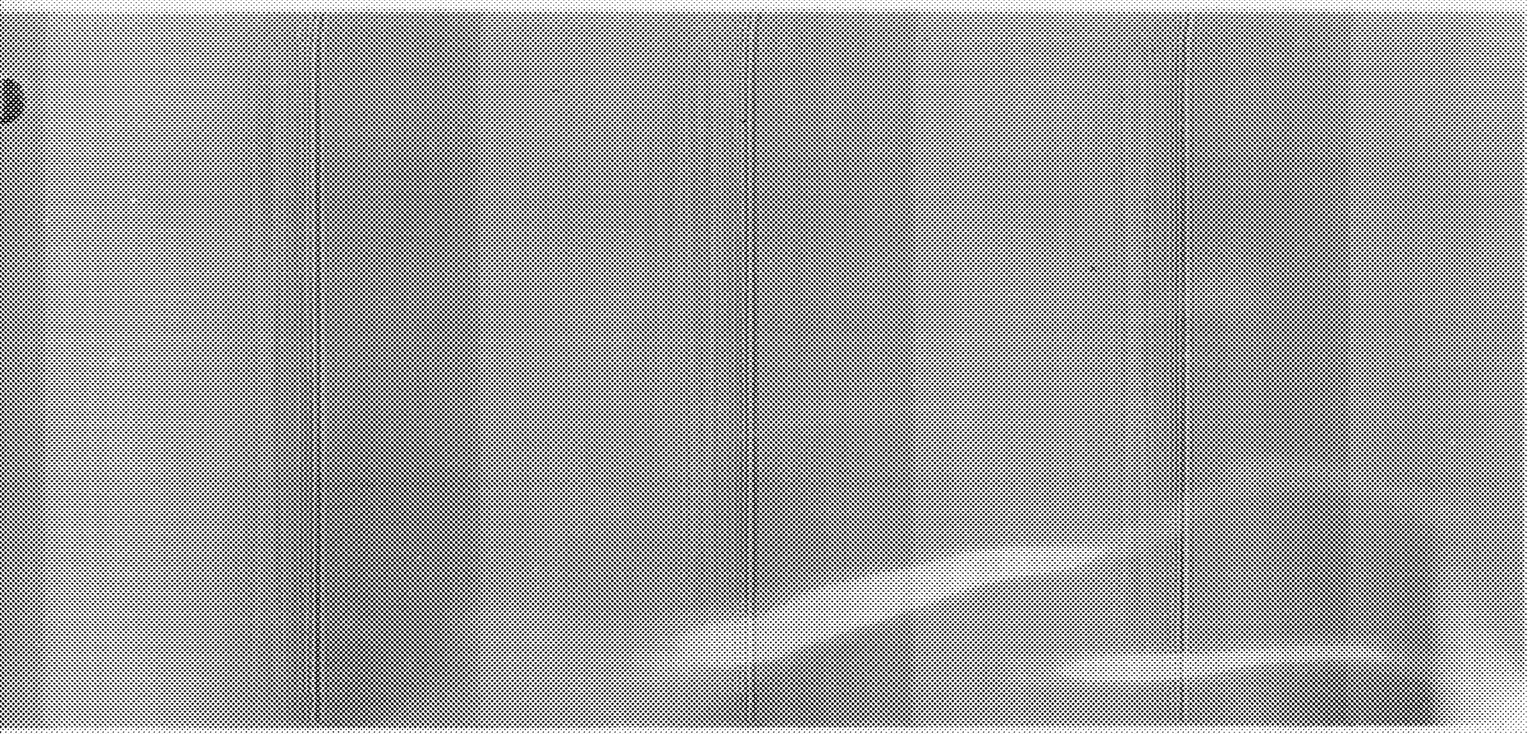


Figure 9A

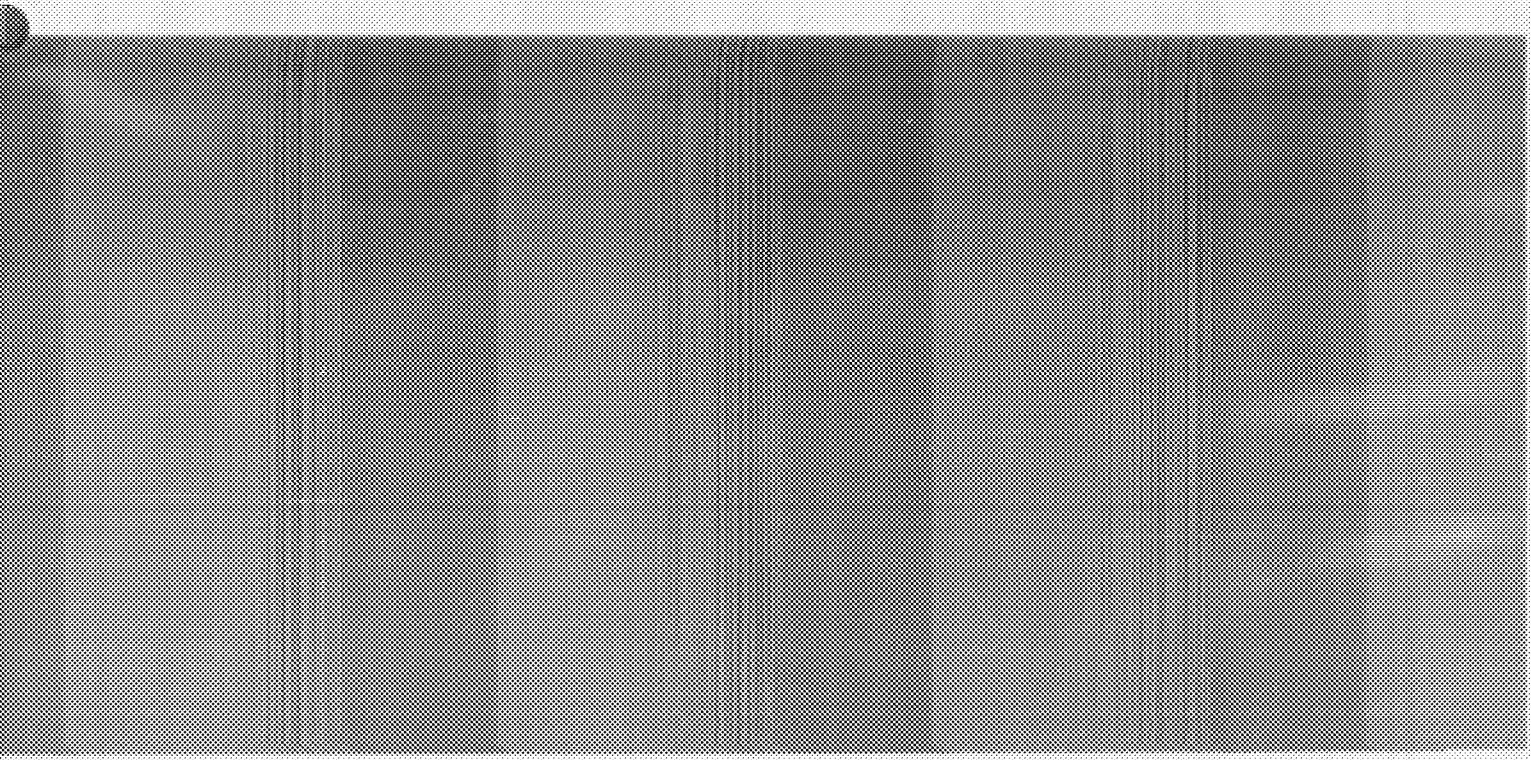


Figure 9B

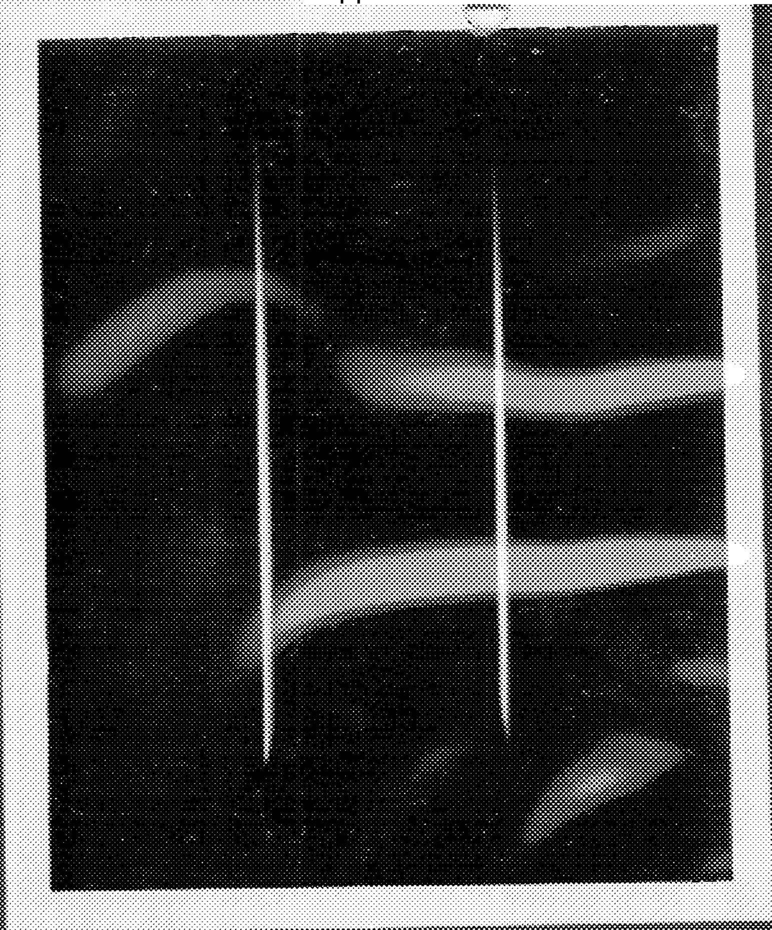


Figure 10

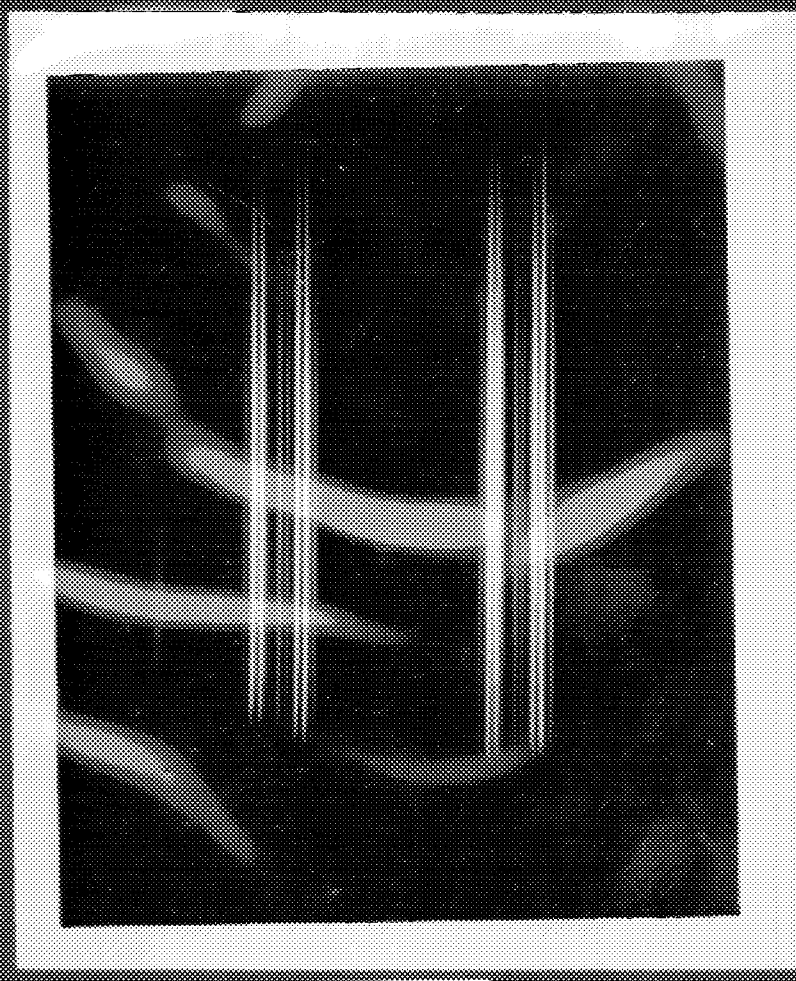


Figure 11

IMAGE FORMATION OF POSITIVE
AND NEGATIVE ZONE PLATES

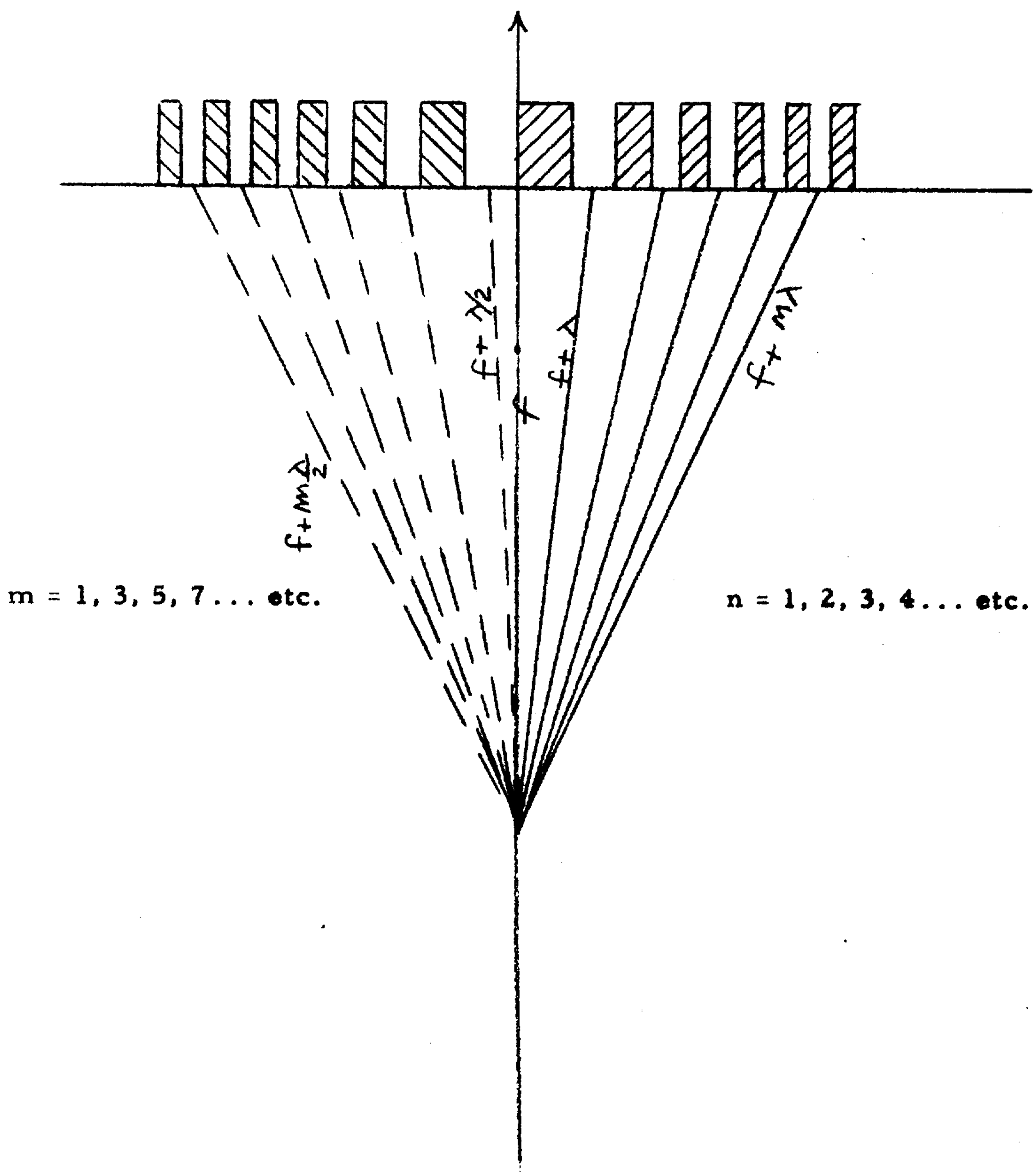


FIG. 12

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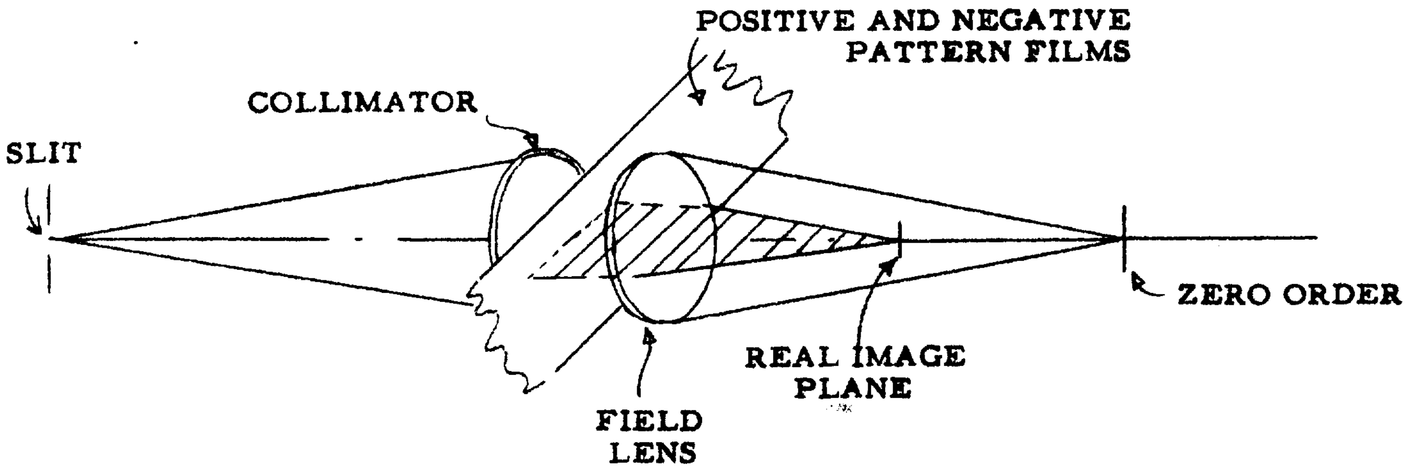

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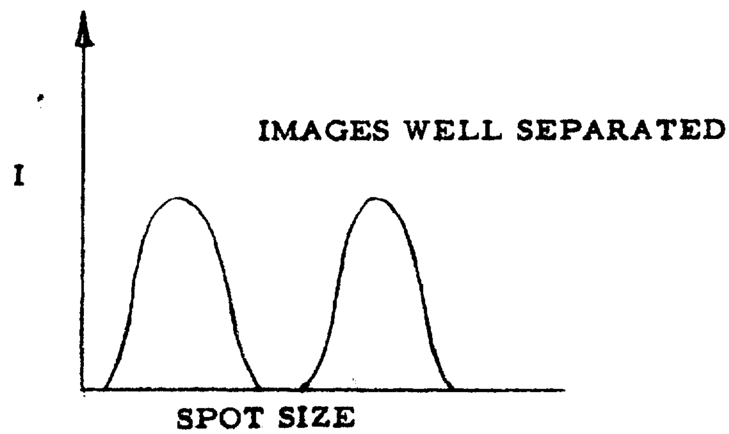

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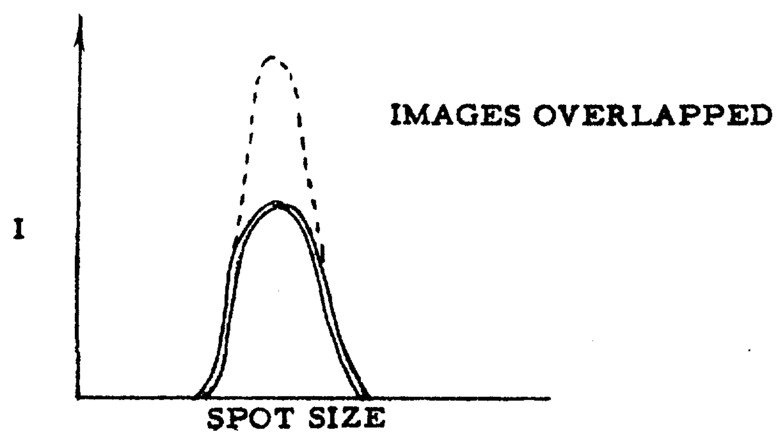

FIG. 13

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COPY 2 OF 3

ITEK LABORATORIES
10 Maguire Road
Lexington 73, Massachusetts

23 January 1963

STAT

Processor Project Report from 1 December 1962 to 1 January 1963

STAT

Performance Studies

The testing of the processor had not been producing the results desired, so the processor and procedures came in for close scrutiny during December. A number of "problems" were identified and efforts started to improve the testing program.

The problems included the following:

a) Stray light: Some of the tests were ruined due to stray light in the film magazine. The problem was traced to a defective screw hole and was corrected.

b) Visual observation: The need for better visual observation has become critical. A ground glass-camera back combination was designed to provide for full field viewing under limited circumstances. A more useful closed circuit television loop system was investigated. An Admiral low light level TV was demonstrated on the processor and its potential value analized. It was recommended that the TV be installed. Figure 1 shows TV setup with the optical bench.

c) Visual to photographic tests: A number of test attempts have proven fruitless because of the difficulty of adjusting the unit so as to record photographically an image which has been obtained visually. The solution to this problem lies in a different slit design and will be incorporated into the TV modification.

d) Film speed ratio: A resolution test run both statically and with moving film showed no loss due to errors in film speed ratio. However, the test was not exhaustive, nor did it provide for calibration throughout the speed ratio range. Some further testing was started to gather data to facilitate setting of the speed ratio to match the optical magnification.

e) Film speed: The speed range of driving the film should be greater. The film could move faster for single target tests, and it needs to move slower for some flight tests. The present speed range of 1:6 (approximately .13 to .78 inches per second on the input film) is inadequate to meet these needs, although it will be adequate for normal operational use. At present this speed range can be shifted by changing a gear reducer; some consideration is being given to building in a quick change gear system.

f) Theoretical information: In attempting to analize the resolution data carefully to see how close it comes to the anticipated capability has shown up two areas where better theoretical data is required. The first unknown is the shape of the spread function for a zone plate. Previous work has been based on a continuous smooth wave as would be produced by a lens. Work has begun on this problem. The second problem is the lack of good aberration data for the cylindrical optical system due to the lack of a skew ray trace computer program for non-symmetrical lenses. These programs will be set up and the data gathered during January and February.

g) Test targets: The testing would proceed more rapidly if the test targets could be aligned to an accuracy of one minute of arc. This accuracy is beyond the capability of present equipment, so has not been specified in the past. However, the lack of alignment has proven very troublesome, and new equipment will be built (or other equipment modified) to provide this capability.

h) Liquid platen: The present platen functions adequately, but it is very difficult to work with. It is impossible to back film more than a few inches for repeat tests, and it is difficult to thread the film. These and other problems were previously recognized and a new design started. The design was completed during December and some tests were started on a dummy glass plate and mounting ring to evaluate a new sealing technique.

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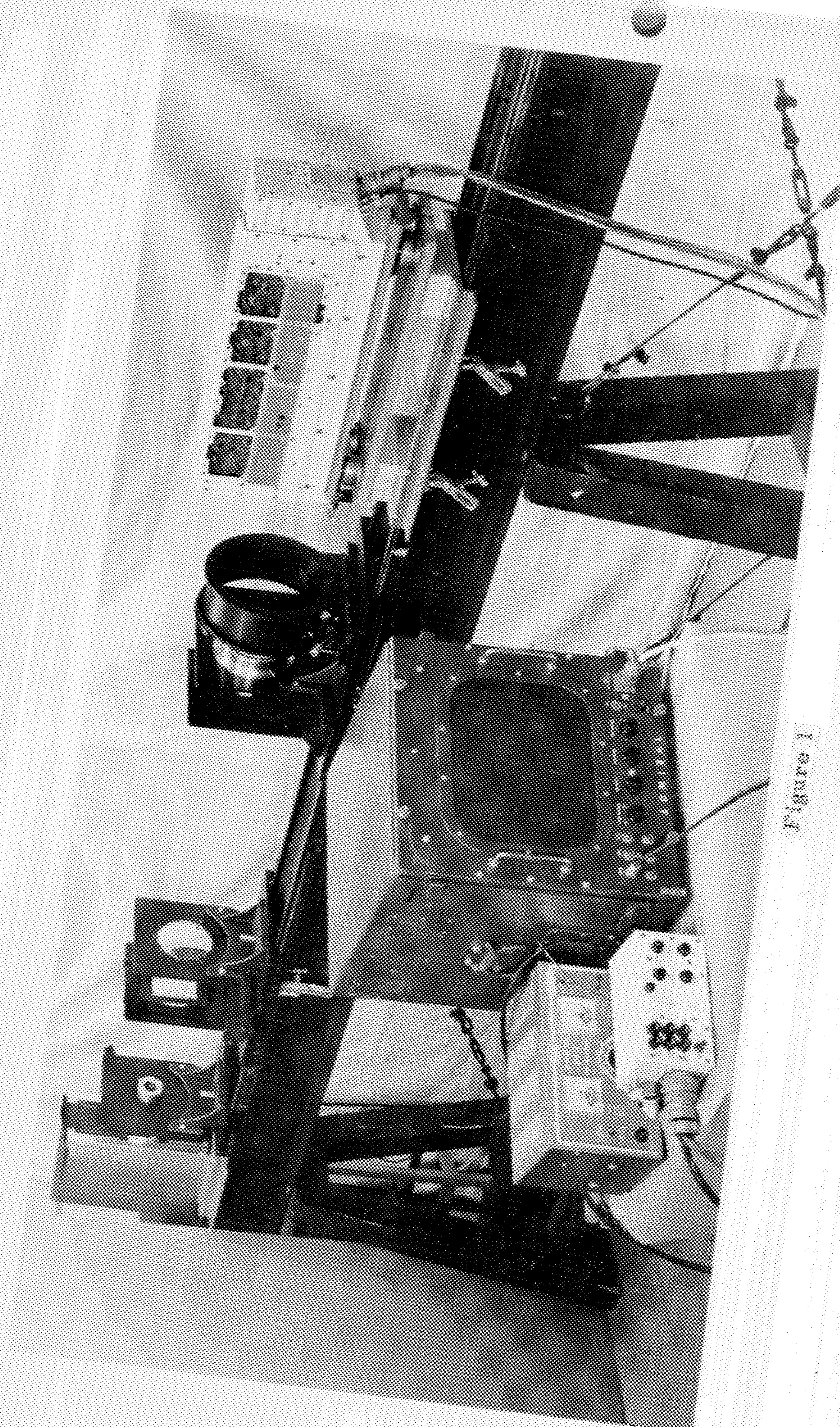

Figure 1